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AN EXAMINATION OF
THE LEVELS OF PROCESSING APPROACH
TO MEMORY

A THESIS

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "An examination of the levels of processing approach to memory; submitted by Michael Joseph Lawson in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

The levels of processing approach to memory proposed by Craik and Lockhart (1972) was examined in a series of three experiments.

Experiment I examined two major questions: the relationship between depth of processing and spread of processing, where spread is defined as further processing within a processing domain; and the nature of optimal encoding strategies adopted in preparation for particular tests of retention. Four groups of subjects were presented with three study lists and were then given either free recall or recognition tests. Two groups completed recall, or recognition tests for all three lists. Each of the remaining groups was switched unexpectedly to either recall, or recognition, tests following presentation of the third list. The purpose of this switch was to allow investigation of the effects of preparation for one type of test on performance in the other test. In general, recognition performance followed the pattern predicted by the levels of processing model, although the performance on phonemic tasks was lower than expected. Recall performance was at a low level for all but the semantic tasks. Further elaboration, or spread, of processing facilitated memory performance for semantic tasks; the extent of facilitation was greater for recall than for recognition. Knowledge of type of test did not produce superior performance in either recall or

recognition, although groups preparing for recall performed better on phonemic tasks than did those anticipating recognition. These results are discussed in relation to the nature of processes involved in recall and recognition, and implications for the postulation of qualitatively different processing domains by Lockhart, Craik, and Jacoby (1975) are noted.

The evidence for qualitatively distinct domains of processing was examined further in Experiment II. This experiment involved a test of the prediction made by Craik and Tulving (1975) that any semantic analysis would be more beneficial for memory than even a complex physical analysis. In addition, a test was made of processing load involved in tasks representative of the three processing domains. Subjects were given three study lists in an unmixed list design. Two changes were made to the procedure used in Experiment I, both of which were intended to provide a more powerful test of the domain hypothesis; a more complex physical task was used, and the nature of the recognition test was modified in such a way that it would be most difficult following completion of the semantic task. While subjects were carrying out the visually presented orienting tasks, an unattended list was presented auditorily. Recognition for words on this unattended list constituted the test of effort or processing load involved in the different orienting tasks. The strong version of the domain hypothesis proposed by Craik and Tulving (1975) was not

given support by results. Semantic processing did not result in significantly better recall or recognition than did the complex physical processing. Levels of recall performance were low for all tasks. Recognition for words on the unattended list was at a similar level for all tasks, suggesting that the tasks did not differ with respect to processing load. Problems associated with the domain hypothesis of Lockhart et al. (1975) are discussed.

Experiment III was an exploratory study which involved an evaluation of the usefulness of levels of processing as a framework for the study of developmental aspects of memory, and also was concerned with an extension of the investigation of the memory component of the simultaneous-successive processing model outlined by Das, Kirby, and Jarman (1975). As one part of a battery of tests, Grade 4 children were given physical, phonemic, and semantic orienting tasks to perform on words within a study list. Subsequently, children were given either a recall or a recognition test. A different pattern of recognition performance was apparent for children than had been found in previous studies with adults. As predicted by results from studies of attribute salience (Underwood, 1969), phonemic processing resulted in comparable level of recognition to that following semantic processing. In recall, semantic processing was superior to either physical or phonemic processing. Girls showed superior recall performance to boys. In recognition, when subjects were divided in High and

Low IQ groups, a difference in level of performance was apparent, though the pattern of performance on the three tasks was similar for both IQ groups. Scores on the recognition test were subjected to a principal component analysis along with scores on the other tests. A pattern of factor loadings similar to that found in previous studies of simultaneous and successive processing was found. Results are discussed with reference to developmental aspects of memory. Problems inherent in interpretation of molar processing models of human abilities are noted.

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In closing I would like to say that it seemed like a good idea at the time.

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INTRODUCTION

In 1972 Craik and Lockhart published a paper which they claimed would:

> . . . offer a new way to interpret existing data and provide a heuristic framework for further research. (p. 671).

In 1976 it appears that their claims were not misleading. The view which they proposed has provided for reinterpretation of data, and has given memory researchers a framework for further research. Three experiments are reported here which investigate some aspects of that framework.

Experiment I is concerned with an examination of two constructs which form the basis of the levels of processing model, 'depth' and 'spread' of processing. Evidence relevant to the two constructs, and to the distinction between them, is based on recall and recognition performance of undergraduate subjects. In addition Experiment I provides an investigation of the nature of optimal encoding strategies adopted by subjects in preparation for different tests of retention. The importance of different modes of processing for recall and recognition processing is examined.

The postulation of qualitively distinct domains of processing within the levels of processing model is examined more directly in Experiment II. The hierarchy of processing domains represents a more precise specification of what is meant by depth in the levels of processing model. Experiment

II also involves a test of the hypothesis that differences between domains of processing represent differences in processes load, or effort.

The final study involves a different subject population. Grade 4 children are tested in a levels of processing study to assess the utility of the levels of processing model for the study of developmental aspects of processing in memory. Finally, this experiment allowed an investigation of the role of recognition memory in relation to the simultaneous-successive processing model of cognitive abilities proposed by Das, Kirby, and Jarman (1975).

LEVELS OF PROCESSING AND MEMORY

In a review of verbal learning and memory in 1970, Tulving and Madigan characterized the two major research traditions in the study of human memory as follows:

> If students of verbal learning are preoccupied with time-temporal contiguity between stimulus and response as the most important necessary condition for the development of an association-then students of memory are preoccupied with space: information is placed or laid down in the memory store or stores, it can be transferred from one store to another, and retrieved in a search through the store. (1970, p. 440).

Though useful in 1970 as a point of distinction between verbal learning and information-processing views of memory, this statement must be modified to provide an accurate representation of research in 1976. The verbal learning approach is no longer concerned with the study of externally contiguous events; the notion of implicit contiguity is proposed as a basis for acquisition (Voss, 1972), and Postman (1972) has outlined the similarity of associative, and more cognitive, organizational, views of memory. Information-processing approaches have also changed. The previous, primarily structural, emphasis has been modified, so that processes operating on those structures are now being given increasing emphasis.

Structure and process models of memory

Until recently most information-processing models of memory were primarily concerned with structural aspects of

memory. The boxes drawn in flow diagrams to represent memory stores became the major focus of study. Hence in the models of Atkinson and Shiffrin (1968), Broadbent (1958), Murdock (1967), and Waugh and Norman (1965), the most common research interests were the characteristics associated with structures - with the various stores represented by the boxes. Such a position was manifest in a representative review of memory (Baddeley & Patterson, 1971) which was organized around the distinguishing features of short- and long-term memory structures. Similarly, studies of malfunctioning memories, such as those with retardates, defined problems of functioning in terms of these specific structures (e.g. Ellis, 1969, 1970). As a result most of the research associated with these models paid less attention to the nature of the arrows between or within boxes than to the nature of the boxes themselves.

Precedents were available for the study of processes (arrows). Miller (1956), though concerned largely with a capacity characteristic of the processing system, suggested ways of operating on stimulus information which would overcome its capacity limitations. In Miller's terms the subject could 'code' material in a reductive fashion. Early studies of organization (Bousfield, 1953; Tulving, 1962) implicated subject-initiated processing strategies in explanation of input-output changes. The structural models themselves also incorporated processes, though these processes were not given detailed consideration. Broadbent's (1958) model provided for a recirculation process between

its storage and perceptual systems and Waugh and Norman (1965) implicated rehearsal processes in the transfer of information between Primary and Secondary Memory. Atkinson and Shiffrin (1968) incorporated these rehearsal processes into their model, with one major modification: they labelled rehearsal a 'control process', and described control processes as "transient phenomena under the control of the subject." (p. 106). However preoccupation with the characteristics of structures appears to have inhibited any detailed investigation of the nature of these control-processes; rehearsal was studied (Norman, 1969), though it was conceptualised at a relatively simplistic level.

Two things have contributed to a change in this situation. The first is a series of theoretical papers concerned with the nature of the memory trace. The second was the somewhat dramatic statement of the processing position made by Craik and Lockhart (1972).

Attributes of memory

Parallel to, but separate from, the concern with structural and control process aspects of memory, there has emerged a view which has served to focus attention on the nature of a memory event. In broad terms, proponents of this view have been concerned with providing an answer to Underwood's (1969) question "of what does a memory consist?"

The answers, which have evinced a fair degree of similarity, have been provided in papers by Bower (1967),

Lockhart (1969), and Underwood (1969, 1972), with a recent expansion of the attribute view being given in papers by Tulving and Bower (1974), and Tulving and Watkins (1975). The Bower and Lockhart positions are described in some detail by Murdock (1974); an outline of Underwood's view is given below.

Underwood (1969, 1972) proposed that an organism's record of an event is composed of an "ensemble of attributes", of a number of different types of information, which serve to establish for that event a unique memory trace. The process by which these attributes are established is known as encoding. Experimentally, the major point of interest is in the effect of the encoding of different types of attributes on memory. Underwood proposed that some attributes (e.g. frequency, spatial and temporal) served primarily a discriminative function, while others, like associative attributes, had largely retrieval functions. In addition, he suggested that the two attribute-types played different roles in recall and recognition processes; according to Underwood, recognition utilized discriminative attributes, recall both discriminative and retrieval attributes (1972, p.6).

In Underwood's case, the attribute papers were perhaps the logical outcome of the distinction he proposed (Underwood, 1963) between nominal and functional stimulus. In both sets of papers he argued for consideration of the active role of the processor in determining what

characteristics were assumed by the memory trace. Furthermore, in both arguments, the focus of attention was shifted to the nature of events occurring at time of encoding, as being influential for subsequent memory performance. It was this latter position which was the basis for Craik and Lockhart's (1972) 'framework for memory research.'

Levels of processing

Craik and Lockhart were not the first to propose a levels of processing analysis of memory in a general form, as they outline in the introduction to their 1972 paper. This paper was however, the most organized statement of the levels of processing view, and was dramatic insofar as the proposal for a new framework was accompanied by a well documented, if unflattering, evaluation of the temporally-structured approach to memory as it then stood. The levels of processing approach is the subject of study here not only for its newness, but also because it has served to reorientate the direction of much research in human memory. Perusal of contents-pages of recent psychology journals will attest to its spreading influence. Finally, and most importantly, it is studied here because the model has been used more than examined. Relatively few studies have been concerned with researching the details of the model; more commonly the levels of processing view has provided a context for discussion of existing data.

The levels of processing model

Craik and Lockhart (1972) made three major criticisms of the multi-store, or temporally structured, model of memory. First, they noted the breakdown in the short-term-phonemic, long-term-semantic coding distinction. Second, they argued against the notion of limited storage capacity in short-term store (the construct proposed for STM), mainly because of the wide variation in estimates of that storage capacity, though they accepted a limitation in the processing capacity of the central processor. Finally, Craik and Lockhart reacted against the multistore view on the basis of forgetting characteristics, stressing again the variation in forgetting characteristics of the three stores. For instance, they noted a range of estimates of persistence of visual features from 0.5 sec to 25 sec. The general thrust of these criticisms was against a view of memory as composed of several specific and discrete systems. Like Melton (1963), Craik and Lockhart argued for a memory system conceptualized as a continuum.

In place of the multistore model, they proposed a "framework for research" which was deceptively simple. They suggested that it: ". . . is more useful to focus on the encoding operations themselves and to consider the proposal that rates of forgetting are a function of the type and depth of encoding (Craik & Lockhart, 1972, p. 673)."

The model as outlined in papers by Craik and Lockhart (1972) and Craik (1973) centers around a continuum of

perceptual analyses. Incoming stimuli are subjected to a number of stages of analysis, initial analyses being concerned with physical or structural features, later, or deeper, analyses with cognitive or semantic processing. The persistence of the memory trace established by the perceptual analyses depends upon the depth, or level, of processing; the deeper, or richer, or more elaborate, the processing, the more persistent the trace. In addition to this basic memory system, a second means of retaining stimuli is proposed--a maintenance of processing at one level. Craik and Lockhart refer to this as "primary memory" (PM), and regard it as synonymous with "keeping the items in consciousness" or "continued attention", or "holding the items in a rehearsal buffer" (1972, p. 676). This continued processing prolongs an item's accessibility, but does not necessarily lead to formation of a more durable memory trace. This maintenance processing, or maintenance rehearsal, is distinct from elaborative processing (or rehearsal) which leads to the formation of richer traces, and thus to improved memory performance.

In his 1973 paper, Craik quoted several studies in support of the primary memory and depth of processing aspects of the model, but left the model substantially the same as in the Craik and Lockhart (1972) paper. Recently, however, substantial additions and refinements have been made (Craik & Jacoby, 1975; Lockhart, Craik & Jacoby, 1975). Now, the distinction between episodic and semantic memory (Tulving, 1972) has been incorporated into the levels of

processing model. Briefly described, episodic memory contains a "temporally ordered collection of all encoded episodes or events" experienced by an individual. (Lockhart et al. (1975) suggests a conveyor belt as an appropriate analogy.) Semantic memory is the individual's "storehouse of generalized knowledge", made up of laws and rules and analyzing patterns, or procedures. It is the individual's cognitive structure and the "homebase" for all encoded traces. The two systems are regarded as interdependent; the semantic memory is structured from episodic traces, and in turn episodic events may be accessed by activating their traces in semantic memory. The episodic-semantic distinction is important for the retrieval aspects of the levels of processing model.

The nature of "levels" is also modified in the most recent version of the model. Incoming information is subject to analyses within three, hierarchically arranged, domains--physical, phonemic, and semantic. Unlike the original model, the analyses carried out within these domains are conceived of as "qualitatively coherent", not as being states on a continuum. Further processing can now take two forms: within a domain, or between domains. The within-domain processing appears to be a "spread" of processing rather than processing at a deeper level. However, both types of processing serve to make the memory trace richer. The nature of the processing is influenced by the task demands, by the familiarity or novelty of the stimulus materials, and by expectations about retention. The importance of depth of

encoding remains; in general, the richer, the more elaborate the encoding, the better the retention.

The construct of spread of processing is a major addition to the theory introduced to provide for the effects of familiarity or novelty of a stimulus. As argued by Lockhart et al. (1975) a stimulus may be processed in a domain to different degrees, on different occasions, or in different contexts. Highly practiced processing skills also imply a spread of processing explanation; proof-readers are obviously more adept at noticing letter inversions than less practiced subjects.

No systematic study of the effects of spread of processing have been made. Therefore the first major question in Experiment I is concerned with the effects of spread of processing on memory performance.

The importance given to retrieval strategies in recent papers reflects a further modification of the levels of processing model. Two retrieval strategies are proposed to be relevant to both recall and recognition. When using a scanning retrieval strategy, the individual choses "some salient aspect" of the retrieval situation and scans recent episodic traces, using the salient aspects to discriminate to-be-retrieved items from items whose traces are in recent episodic memory. This strategy is suggested to be optimal for recent memory.

The "guided reconstruction" strategy can also be used

for recent events and is necessary for retrieval of remote events (those not in recent memory). In recognition, this retrieval-by-reconstruction operates through:

> . . . a process in which some approximation to the initial encoding of the event is reconstructed in the perceptual/cognitive system. The reconstruction is guided and constrained by the recognition stimulus on the one hand and information from the episode trace on the other. (Lockhart, Craik & Jacoby, 1975, p.14).

This reconstructive process also operates in recall, though in that task the individual receives only minimal retrieval information from the test situation.

These represent the major aspects of the levels of processing model. Depth of processing is retained as the basis of the model, and is defined in terms of the three qualitatively different domains. A new construct, spread of processing, represents further elaboration within a domain. Retrieval, within the model, is of two types, scanning and reconstruction.

Evidence for the levels of processing model

Craik (1973), Experiment IV,asked subjects to carry out five different orienting tasks on words in a list, each task being applied to eight words in the list. After all words had been presented, an unexpected recognition test was given, the results of which are given in Figure 1. Craik argued that each of the orienting tasks required subjects to process the words to different (deeper) levels, and suggested that "subsequent recognition performance was a function of the initial processing depth (1973, p.59)".

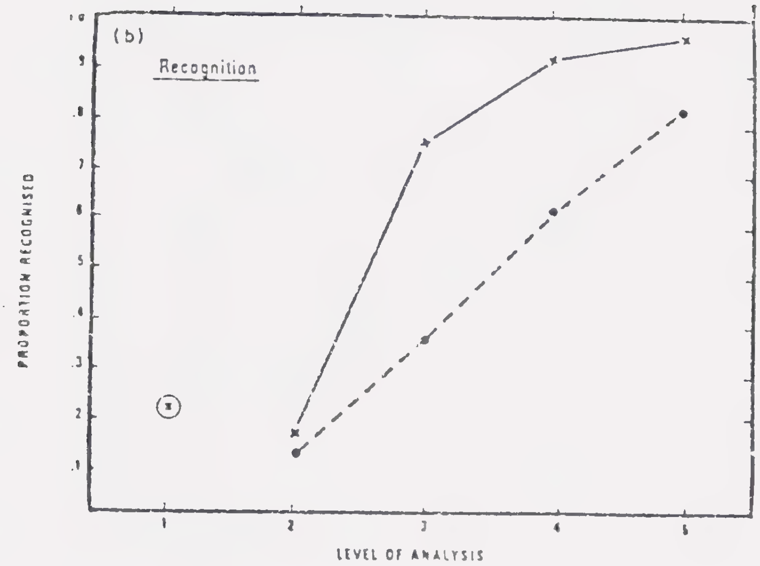

FIGURE 1. Recognition performance as a function of levels of analyses. (x) Yes questions; (.) No questions (Craik, 1973: Experiment IV)

This incidental learning paradigm has also been used in a series of studies by Jenkins and his colleagues (Hyde & Jenkins, 1969, 1973; Till & Jenkins, 1973; Walsh & Jenkins, 1973; Jenkins,1974). In these studies, tasks requiring subjects to attend to semantic aspects of words produced higher levels of recall and associative clustering than tasks which oriented subjects toward formal, non-semantic features of the words. The same pattern of results emerged using both related and unrelated words as stimuli, in incidental and intentional learning conditions, and for within-subjects and between-subjects designs. Jenkins, however, does not identify levels of processing beyond those invoked by semantic and non-semantic tasks, and does not involve retrieval processes in his explanation of the effect. Even so this approach is remarkably similar to that of Craik and Lockhart (1972); "The chief difference between the various orienting tasks may be one of richness made available by the analysis needed to perform the task (Jenkins, 1974, p. 18)." Other researchers have invoked a levels of processing explanation for effects in directed-forgetting tasks (Timmins, 1974), sentence comprehension (Mistler-Lachman, 1974), and processing of pictures (Bower & Carlin, 1974).

The major series of studies of direct relevance to the model is reported in a paper by Craik and Tulving (1975). On the basis of results from the first five experiments Craik and Tulving conclude that differences in recall and recognition performance following different orienting tasks

were not simply a function of processing time (response latency). In Experiment 5 they replicated a study by Gardiner (1974), and, like Gardiner, found that a complex physical task which took longer to complete than a semantic task yielded a lower level of recognition than did the semantic task. Craik and Tulving also explored the difference in level of performance following positive and negative responses to orienting questions. To explain the superiority of positive responses on semantic and phonemic tasks they invoked the notion of congruity of encoding put forward by Schulman (1974). Results from their Experiment 6 suggest that in certain tasks, congruity, or coherence, of encoding is an important variable. When subjects were given tasks which involved comparisons along dimensions such as sharpness, value, size, and temperature, positive and negative categorization decisions did not result in recall differences. The implication drawn by Craik and Tulving (1975) was that because such comparisons did not result in differences in congruity, or richness, of encoding (whether answer was Yes or No), then recall levels were similar for both types of response.

Other studies reported by Craik and Tulving (1975) involved the generalization of the levels of processing paradigm to group-testing situations using different presentation rates, in each of which the same pattern of performance found with individual testing was apparent. Finally, one study (Experiment 7) was a preliminary investigation of the effect of further elaboration of

processing within the semantic domain. For positive responses, greater complexity of task was associated with higher level of recall.

The suggestion that quantity and quality of processing should be differentiated is supported by the results of recent rehearsal studies. Craik and Watkins (1973) showed that increased frequency of overt rehearsal did not improve recall of recency items on either immediate or delayed recall tests. Jacoby (1973a) found that the final free recall of short word lists was no different for subjects who had rehearsed words overtly than for subjects asked to recall immediately after list presentation. Thus it appears that maintenance of items does not necessarily lead to improved memory performance. The failure to find an isomorphic relationship between frequency of rehearsal and recall is supported by the findings of Einstein, Pelligrino, Mondani and Battig (1974). Both sets of findings argue against the conclusions of the study by Rundus (1971) in which greater frequency of rehearsal is assumed to lead to improved recall.

The utility of the distinction between maintenance and elaborative rehearsal is given further support by the findings of Mazuryk and Lockhart (1974) and Watkins and Watkins (1974). Mazuryk and Lockhart gave subjects four types of rehearsal; silent, overt repetition, overt generation of rhymes, and overt generation of associates. On immediate recall tests the overt repetition and silent

rehearsal conditions produced better recall. However, on a final recognition test the group which generated verbal associates recognized more words than did any of the other groups. The authors drew two implications from the results. First, that the more elaborate the processing of information, the more available the memory trace for later retrieval. In addition, they suggested that different types of rehearsal were optimal for immediate retrieval, others for delayed retrieval.

Watkins and Watkins (1974) came to a similar conclusion. They informed half of their subjects about list length and withheld this information from the other half. The informed group, who could anticipate recency items, recalled these items better on an immediate recall test than did the uninformed group. The latter, however, showed superior recall for recency items on a delayed, final free recall test. The implication of these results for level of processing model is that the uninformed group processed recency items more elaborately, and thus richer traces facilitated delayed recall. Watkins and Watkins (1974) noted that the recall performance of the informed group showed a negative recency effect on final free recall, and proposed that the negative recency effect (Craik, 1970) is related to maintenance processing of recency items. This effect was not present in final free recall of the uninformed group.

The suggestion that different levels of processing are undertaken depending upon the subject's expectation (e.g.,

of list length) is supported by studies in which subjects' knowledge of retention interval was varied (Jacoby & Bartz, 1972; Gotz & Jacoby, 1974). In the Gotz and Jacoby (1974) study, when retention was tested after a delay, performance was higher for those who expected the delay than for subjects who expected retention after a shorter interval.

The results of the studies reviewed in this section suggest that there is support for three major aspects of the levels of processing model. The studies by Craik (1973) and Jenkins (1974) show the powerful influence of different orienting tasks on subsequent retrieval. These studies also indicate the importance of semantic processing for recall and recognition, though they do not indicate why this might be so. Second, the treatment of rehearsal in the levels of processing model is supported by the data. Both the role of maintenance rehearsal in recency, and the importance of elaborative rehearsal for delayed retrieval, are consistent with results of these recent studies. Finally, the idea of optimal encoding is implicated in the results of studies which varied subjects' expectancies about list length and retention interval.

The levels of processing model, through its emphasis on different depths of processing, appears to be an appropriate framework within which to investigate the nature of optimal encoding strategies. Thus the relation between different levels of processing and optimal encoding strategies for recall and recognition tests will form the second question

of major interest in Experiment I.

In regard to other aspects of the level of processing model, evidence is conflicting or nonexistent. Craik (1973) proposed that diversion of attention from an item should lead to complete short-term forgetting of the item. This view was modified by Craik and Jacoby (1975) in the light of evidence of less than total forgetting in PM in the studies of Shiffrin (1973) and Reitman (1974). The exact relationship between Primary memory and 'recent memory' is not clear from present descriptions of the model. Watkins (1974) has indicated some problems with the view of Primary Memory described by Craik and Lockhart. Recent memory appears to be a type of working memory similar to that proposed by Baddeley and Hitch (1974) and Shiffrin (1975).

The evidence supporting the distinction between scanning and reconstruction retrieval strategies is meagre. Craik and Jacoby (1975) report results of one study showing no differences in immediate recognition for semantic, phonemic and structural tasks, but superiority of the semantic task for final free recall. However, they note that "attempts to replicate the finding have yielded inconsistent and noisy data (p. 19)".

Issues related to the levels of processing model

Levels of processing and other memory models

The general importance of considering different levels of processing and their effects on memory has been

acknowledged in most recent considerations of memory. Herriot (1974) has designed his small review of recent memory research around the notion of levels of coding. As mentioned previously, the research journals involved with memory contain a relatively large number of articles concerned with a levels of processing explanation of results. In a recent symposium on models of short-term memory (Restle, Shiffrin, Castellan, Lindman, and Pisoni, 1975) the models outlined by Bjork (1975) and Shiffrin (1975) made explicit provision for a levels of processing viewpoint, though these authors differed with Craik and Jacoby (1975) as to the locus of the processor, and its relationship with short-term and long-term stores. In another theoretical paper Restle (1974) outlined a levels of processing approach based upon organization theory.

Criticism of the levels of processing model is not widespread. Murdock (1974) raises some problems for the levels of processing view, the most crucial of which is the inadequacy of the definition of 'depth'. A similar argument is made by Tulving and Bower (1974 p.274).

The most direct disagreement with the levels view is contained in the work of Kolers (1975). Kolers rejects both attribute and levels of processing views. The mind, in his view, is not composed of "concepts, ideas and images", and it does not work by "sorting, comparing, and coding them." Rather, he holds the alternative view that:

> . . . the mind is procedure, operation, and activity; and that what it knows is what it knows how to do.

(p.689)

Essentially, Kolers appears to object to two features of the levels of processing model. First, he rejects the notion of fixed, "rigidly programmed," stages of analysis i.e. he argues against the hierarchy of processing domains proposed by Lockhart et al. (1975). In addition, Kolers rejects the ordering of the domain hierarchy; he subscribes to a view, perhaps more flexible than that of Lockhart et al. (1975), which does not give primary emphasis to semantic processing for memory. For Kolers (1975) "procedural knowledge", knowledge of operations, represents a plausible alternative to semantic analyses as the substance of memory.

Recall and recognition

Lockhart, Craik and Jacoby's (1975) conceptualization of the relationship between recall and recognition is distinct from other current thinking about these two retrieval modes. For Lockhart et al. recall and recognition represent two different questions asked of a common system:

> We believe that recall and recognition do not differ in any crucial way--they are different only in the sense that in recognition representation of the stimulus provides better information from which the initial encoding can be reconstructed (p. 19).

Like Anderson and Bower (1972), they reject the view that recall and recognition differ in terms of strength thresholds (Wicklegren, 1970). Similarly, they do not accept the frequency theory explanation of recognition advanced by Underwood and Freund (1970), preferring an explanation of word frequency effects in terms of number and nature of

encoding operations, rather than in terms of a "frequency unit" score. As indicated previously, Lockhart et al. consider recall and recognition as essentially similar, differing only in the amount of information supplied to the individual at time of test. Thus both generation-recognition models and Anderson and Bower's (1972) context-retrieval model are criticized; the first because of its implication that recognition is an automatic addition to a search process, and the context-retrieval view because it does not provide for "guided" reconstruction of the memory trace.

In the levels of processing model, the question of a retrieval component in recognition is therefore replaced by that which asks "What kind of retrieval, scanning or guided reconstruction?" In positing this view Lockhart et al. (1975) emphasize the importance of giving consideration to retrieval conditions. Quite correctly they point out that the retrieval situation involves an interaction between the memory trace and the memory probe-as-encoded at time of test. In their view, whatever the nature of the test, one or the other retrieval mechanism is operative.

Optimal encoding

Lockhart et al. (1975) make provision for one additional control process in their model - a "set" associated with processing for a particular type of retention test. The idea is not new. Carey and Lockhart (1973) proposed such a view and obtained evidence for

different "modes of processing" in recall and recognition. Freund, Brelsford, and Atkinson (1969) and Loftus (1971) also proposed similar effects. These and other studies will be reviewed in more detail in the introduction to Experiment I. The significance of these control processes here is that the levels of processing model allows a suitable means for investigating their operation in more detail. If preparation for a particular type of test involves use of certain attributes, as Underwood (1969) argues, then evidence relevant to this argument could be provided by the use of orienting tasks in the levels of processing paradigm.

Other issues

Craik and Lockhart's (1972) approach is compatible with principles established in several different fields of research in memory.

The strong emphasis placed by Craik and Lockhart on encoding was similar in essence to the encoding specificity principle of Tulving and Thomson (1973):

> . . . that only that can be retrieved that has been stored, and that how it can be retrieved depends on how it was stored. (p. 358)

Encoding specificity is in many ways a restatement of the attribute theories already discussed, and as such is quite compatible with the levels of processing emphasis on the role of encoding operations for durability of the memory trace.

Craik and Jacoby (1975) also relate the questions of

capacity and consciousness in their description of primary memory. A limited capacity processor is one of the central features of their system. The current products of the operations of this processor form "conscious attention". Such a view is substantially in agreement with those of Bjork (1975) and Mandler (1975), though the exact terms of description of the two concepts differ among authors.

Finally, the utility of the levels of processing procedure for the study of both developmental aspects of memory and individual differences can be determined. The developmental implications of the levels of processing model arise primarily from studies investigating predictions based on attribute theory.

Studies by Bach and Underwood (1970), Felzen and Anisfeld (1970), and Freund and Johnson (1972) all suggested that the influence of physical and phonemic attributes was more potent in children than in adults, for whom semantic attributes assumed most importance.

A similar conclusion emerged from the study by Pender using the release from proactive-inhibition paradigm (Peterson and Peterson, 1959). [Pender's study is reported in Wickens (1972, pp 200-202)] In this study college students appeared to be less sensitive to rhyming characteristics of words than either second- or sixth-grade children.

The use of the levels of processing procedure is

suggested to be particularly appropriate as a means of gaining converging evidence relevant to the developmental differences noted in the above studies.

Underwood (1969) also speculated about possible individual differences in encoding though very little has been done to take up this point since that time. The levels of processing model would also appear to be a useful framework for taking up the investigation of differences in processing. Thus patterns of processing in different ability groups could be investigated. Very little research has been directly concerned with the encoding processes of such groups. Even researchers concerned with the study of the mentally retarded child have neglected qualitative aspects of processing. Zupnick and Forrester (1972) presented semantically and acoustically related word lists to third-grade and MA-matched retardates but found no interaction between IQ and list type.

In a study using physiological indices, Luria and Vinogradova (1959) studied encoding in subjects of differing degrees of retardation. In normal children (11-12 years) orienting reactions were evoked by semantic 'connexions' of a target word, but not by acoustic 'connexions'. The converse was the case for the retarded. As the degree of retardation increased the reactions to acoustically-related words became more dominant.

The conclusions of Luria and Vinogradova suggest that a similar pattern may begin to appear in subjects completing

different orienting tasks in the levels of processing procedure. This will be one subject of investigation in Experiment III.

Finally, the relation between memory and other processes in the elementary school sample will be investigated briefly. This question will be taken up in more detail in the next section.

Summary and conclusions: levels of processing and memory

This section has reviewed the perspective within which the levels of processing framework was proposed, and has reviewed both descriptions of the model and evidence in support of it.

The levels of processing model is one which places emphasis on processes operating within existing cognitive structures, rather than on the structures themselves. It is seen to be related closely to the view of memory as a collection of attributes. The model is described in terms of three major features: the emphasis it places on encoding; the importance of depth of processing for subsequent memory; and the distinction between maintenance and elaborative rehearsal. Recent additions to the model have introduced two major innovations; the concept of spread of processing, or further elaboration with one of three, hierarchically arranged domains; and the proposal for scanning and reconstruction retrieval strategies.

The evidence currently available generally supports the qualitative emphasis in the model, as being more important for memory than quantitative parameters such as time of processing. Findings from several other studies support the role assigned to semantic processing within the model. Recent studies directly related to the levels of processing approach have made use of the concept of congruity of encoding in explanation of performance differences following positive and negative categorization decisions.

A number of issues related to aspects of the model have been outlined in brief. Recent models of memory, both long-term and short-term, have incorporated the notion of levels of processing. Two major points of criticism have emerged: the inadequacy of the definition of depth of processing and the hierarchical arrangement of stages of processing. Kolers (1975) has proposed a procedural alternative in explanation of recognition memory effects.

Recall and recognition are treated in a way different to both one- and two-process models currently extant in the literature. Both recall and recognition are claimed, in the levels of processing model, to involve retrieval; differences between the two are stated in terms of amount of information supplied at time of test. The levels of processing approach, in recent versions, has given much-needed emphasis to retrieval conditions. In addition the relevance of the model for the study of optimal encoding strategies utilized for particular tests, and possible

developmental and individual differences applications have been reviewed.

It has been suggested that the study of the levels of processing model is warranted on three grounds: the general significance of the approach for the reorientation of memory research; the relatively small amount of research currently available which has investigated details of the model; and the potential utility of the model for investigation of developmental and individual difference aspects of memory.

SIMULTANEOUS - SUCCESSIVE PROCESSING

Memory is but one component of a larger information-processing system, though for memory theorists most of this system is taken up with encoding, storage, and retrieval. Study of this larger system is necessarily more molar than molecular, and, traditionally, methods of investigating its operation have been correlational.

Recently, the emphasis within the literature concerned with the study of human abilities has come to reflect the increasing influence of the information-processing point of view, and as in the case of memory models, processes have been given increasing attention.

Messick (1972) outlined a hierarchical model of processes extending from general processing strategies into much more specific types of processes, or abilities. Messick argued for recognition of the fact that differences in processing may extend through each level of the hierarchy, from specific abilities to the level of general processing strategies, subject to demands of the task and to processes under the control of the subject. At a slightly more concrete level the same point was made by Estes (1974), who indicated that, even for a relatively simple task, subjects may possess idiosyncratic processing strategies. To some extent these views echo Underwood's (1963) call for a distinction between nominal and functional stimuli; the task

must not be assumed to dictate the process used by the subject.

Carroll (1974) has suggested a method for investigating the operation of processes in a wide range of cognitive tasks. In essence his method involves analysis of tests in terms of a model of processing, and then a subsequent factor analysis of test scores to confirm the validity of the original test analysis. As an example, Carroll analysed a number of psychometric tests in terms of their possible involvement with the components of the "distributive memory model" of Hunt (1971), and then showed the (hypothetical) multifaceted nature of these tasks in terms of the memory model. Carroll did not however extend his work beyond the task analysis stage. A related approach which has involved factor analytic investigations of processing involved in various tests has been developed by Das and his colleagues (Das, Kirby, and Jarman, 1975).

The simultaneous-successive processing model

Das, Kirby and Jarman (1975) have described a model of cognitive behavior based upon a distinction between simultaneous and successive processing of information. The basis for the model may be found in the neuropsychological investigations of Luria (1966;1973). Luria proposed the existence of "two basic forms of integrative activity of the cerebral cortex (1966, p. 74)", simultaneous and successive syntheses:

> The first of these forms is the integration of the individual stimuli arriving in the brain into *simultaneous, and primarily spatial groups*, and the second is the integration of individual stimuli arriving consecutively in the brain *into temporally organized, successive series*. (Luria, 1966, p. 74)

Luria's work was based on the study of brain-injured patients using a technique which he termed "syndrome analysis". With these patients this involved consideration of all patterns of behavior associated with a particular cortical lesion and search for "intrinsic similarities between apparently totally different psychological processes (Luria, 1973, p. 41)".

Das and his colleagues have developed their model of processing from work with quite different populations. In the model depicted in Figure 2, they describe four basic units; input, sensory register, central processing unit, and output. Information presented to any of the receptors may be presented in a simultaneous or successive manner and is registered in the sensory register. In this unit processing may be either serial or parallel. The products of this processing are then operated upon by the central processing unit. The output unit then organizes the products of central processing in accordance with the demand of the task.

Three components of central processing are singled out in the model: simultaneous processing, successive processing,and a decision-making and planning component which uses the information processed by the other components. The simultaneous and successive components operate at three levels; perceptual, mnestic (memory) and

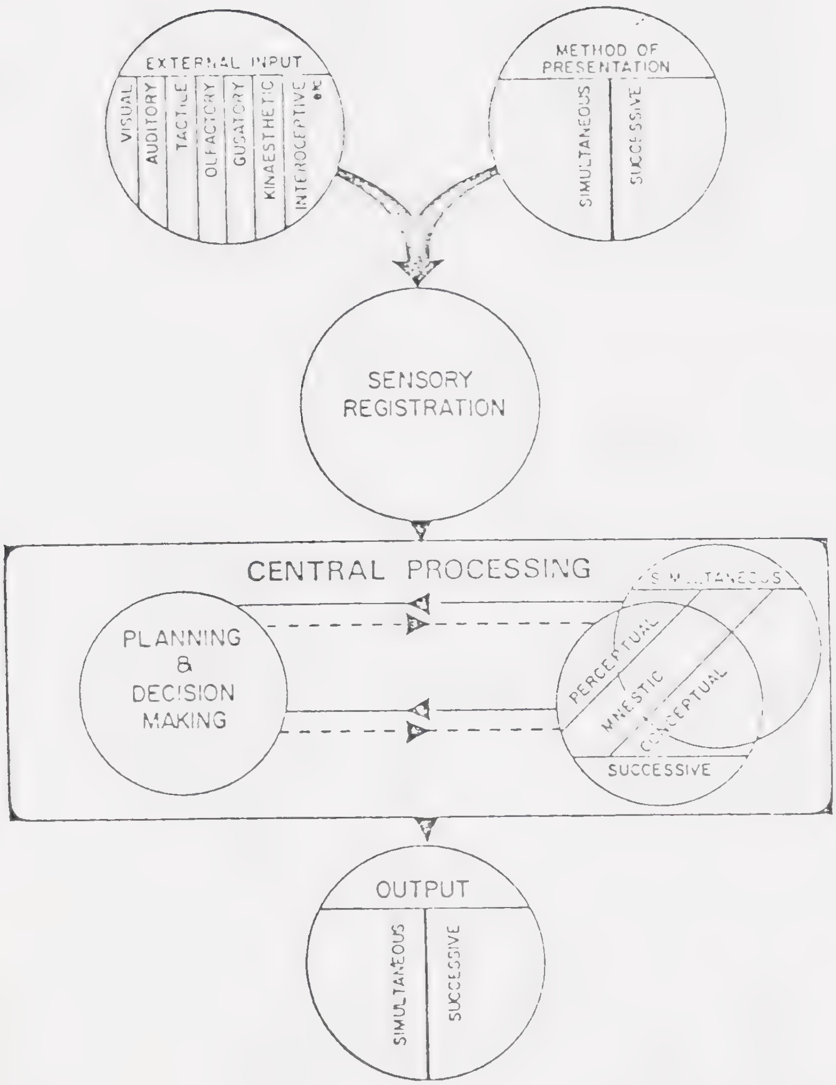

FIGURE 2. Model of information integration.
(Das, Kirby, & Jarman, 1975)

conceptual. It is the operation of simultaneous and successive processing which is of central interest in this study.

Evidence for the model: Factor analytic studies

Das et al. (1975) review a number of factor analytic studies of cognitive tests in which simultaneous and successive processing factors have been identified. Table 1 on the following page gives the factor loadings for the tests used in the Das (1973) study.

The first factor is related most strongly to tests which involve successive processing. Both serial recall and visual short-term memory tests involve memory for auditorily presented series, the first with words, the second using numbers. Cross-modal coding requires the subject to identify visually a series of dots which was initially presented acoustically. The tests do not reflect either modality specific or material specific processing. Nor is the factor solely a memory factor for the Memory for Designs test loads on a separate factor. (The Free Recall score in this battery was derived by an alternative scoring of the Serial Recall test--an anomaly which suggests that it should be replaced by a separate free recall test.)

Factor II loadings relate most clearly to school achievement factors. As Das et al. (1975) note, this factor is similar to Vernon's verbal-educational factor. The fact

Table 1

Rotated Factors (Varimax) for Cognitive and Achievement Tests:

Edmonton High and Low SES Children (N=60)

Variables	Factor I Successive	Factor II School Achievement	Factor III Simultaneous	Factor IV Speed
I.Q. (from school records)	.347	.793	.204	.045
Raven's Progressive Matrices	.181	.384	.740	.200
Figure Copying	.162	.157	.674	.004
Memory for designs	.178	-.055	-.830	-.162
Cross-modal Coding	.457	.059	.433	.423
Visual short-term memory	.760	.034	.124	.462
Serial recall	.896	.355	.042	.013
Free recall	.898	.340	.004	.019
Word reading	-.130	-.320	.045	-.879
Reading achievement	.184	.851	.100	.266
Math achievement	.161	.844	.281	.152
% of total variance	24.2	23.5	18.5	12.1

that the composite (verbal+non-verbal) IQ scores, claimed to reflect general reasoning, load most highly on this factor, reinforces the description of Factor III as representing simultaneous processing rather than reasoning.

Factor III is marked primarily by loadings on Raven's Progressive Matrices, Figure Copying and Memory for Designs tests, each of which involve spatial integration of information. This factor, then, is not solely a reasoning factor (which might be suggested by the high loading of Raven's Progressive Matrices). The involvement of spatial integration of elements suggests that simultaneous processing is an appropriate label. The speed factor has been identified in several of the studies reviewed by Das et al. (1975); it is described as being "like the speed of integration of information (p. 93)".

Further investigations of the simultaneous-successive processing model have been carried out by Jarman (1975), using low, average and high IQ groups; Krywaniuk (1974) who studied processing in Canadian Indian children; Leong (1975) in a study of disabled readers; and by Das and Molloy (1975). In general these studies have indicated that the simultaneous and successive factors emerge for a variety of subject populations, though different patterns of loadings are apparent for diverse groups. For example, in the study by Das (1972) in which retarded and normal children of comparable mental age were compared, differences in loadings for certain tests were present for the two groups. Within

the framework of the model such differences in factor loading patterns are assumed to reflect differences in processing strategy.

Other evidence for simultaneous and successive processing

The concepts of simultaneous and successive processing are not new in psychology. Research on serial and parallel processing has been of major interest to students of perception, communication and memory. Neisser (1963) found evidence of parallel processing of simple stimuli but not for more complex and spatially distinct stimulus material. Saraga and Shallice (1973) proposed a parallel processing of simple geometrical shapes. Sternberg (1966) used reaction times for searches of subspan lists of digits to infer serial scanning of information; he found that reaction times increased as a linear function of number of alternatives. The nature of the scanning process has been the subject of controversy, for both parallel and serial explanations have been proposed. This issue has not been settled, for Murdock (1974) reports a study by Burrows and Okada which argues for parallel processing of supraspan lists. Egeth, Atkinson, Gilmore and Marcus (1973) have argued for a view closely related to that advanced in the simultaneous-successive model. They propose that serial and parallel processing modes are subject to control processes at the option of the individual.

In a more general sense Paivio (1971) has argued for

"sequential" and "synchronous" processes, the first specialized for the verbal system, the latter for processing of visual, imaginal information. Finally, there is a considerable body of research concerned with hemispheric differences in processing. Milner (1971), Ornstein (1973), and Bever and Chiarello (1974), all consider the likelihood of two basic types of processing similar in essence to simultaneous and successive processing.

The simultaneous-successive model is more parsimonious than that proposed by Carroll (1974); three major factors are implicated rather than the 24 which Carroll hypothesized would be necessary to represent the "response consistencies" present in tests he analyzed. This parsimony of number of factors is associated with broad rather than specific factors, and at the present stage of development of the model the breadth of the factors limits the precision with which inferences can be made from particular factor loading patterns.

In the final study reported here the memory aspects of the simultaneous-successive model will be investigated. While the battery of tests used in previous studies have included some memory tests, neither free recall nor recognition scores have been included in previous analyses.

RATIONALE FOR EXPERIMENTS

The three studies reported here are all investigations of the levels of processing model. Experiments I and II involve separate examinations of the depth, and spread hypotheses which form the basis for the model. Experiment III is a preliminary investigation of the applicability of the levels of processing model to developmental and individual difference questions. As the rationale for each experiment is developed in the introduction to each separate study, the general rationale for the studies will be reviewed in brief at this point.

Experiment I

While the notion of depth of processing has been the subject of some investigation, the equally significant spread of processing hypotheses has been given minimal attention. The only substantive investigation of the hypothesis is that contained in Craik and Tulving's (1975) Experiment 7. This construct, spread of processing, would appear to be a necessary modification of the depth of processing theory on logical, as well as, empirical grounds. Evidence such as that quoted by Kolers (1975) attests to the potentially powerful effects of relatively complex physical processing tasks on memory. It is possible that such phenomena could be accommodated within the levels of

processing view by the spread of processing construct. The within-domain elaboration hypothesis would also appear to be a necessary corollary of the rather restrictive proposal for the existence of three qualitatively distinct processing domains. If within-domain effects could be documented, the model would be given much greater flexibility in accounting for differences in memory performance. Thus the relationship between depth and spread of processing is one of the questions of major interest in this study.

The second major question investigated in Experiment I involves the use of a levels of processing procedure to investigate optimal encoding strategies. Several studies have shown that subject performance is best when they know in advance which type of test will follow. Underwood (1969) suggested that this effect may be due to us of attributes which are optimally useful, say for a recognition test. If such is the case, the levels of processing procedure involving different orienting tasks could elucidate the roles of three distinct attribute types in subjects preparation for either recall or recognition tests. Hence, in this study subjects preparing for both types of test will be given different orienting tasks; the effect of task on test expectation will be the major point of interest.

Experiment II

Depth of processing has been operationalized in terms of three qualitatively coherent domains by Lockhart et al.

(1975). "Qualitative coherence", it is argued, will be reflected in performance differences, i.e. semantic processing will yield recall or recognition scores which are significantly superior to those resulting from either physical or phonemic processing. From the domain hypothesis it also follows that phonemic processing will produce a corresponding superiority of performance when compared to physical processing. This position has been stated clearly by Craik and Tulving (1975) when they claim that any semantic analysis will always be more beneficial for memory than any physical processing. Up until this time this prediction has not been given any very stringent test. Thus the major concern of this second study will be to provide a more powerful test of this prediction derived from the domain hypothesis.

A subsidiary aim of this study involves an investigation of the role of processing load, a quantitative parameter, in determining differences in performance following tasks which are claimed to be qualitatively different.

Experiment III

The final experiment is concerned with application of the levels of processing model to the study of developmental differences in memory, and also involves a preliminary investigation of the memory component of the simultaneous-successive processing model.

A number of studies reviewed previously have argued for changes in the salience of particular attributes with changes in age. If such is the case, the differences noted in the attribute studies should be reflected in a levels of processing procedure. This latter procedure also provides a more systematic theoretical framework within which to conceptualise memory processes than does attribute theory. Therefore this final experiment will involve the use of a levels of processing procedure with an elementary school population. The scores on the memory tests will also be included in factor analysis of a battery of test scores to provide evidence relevant to the role of memory in relation to simultaneous and successive processing.

EXPERIMENT 1

Depth of processing has been defined more precisely in recent versions of the levels of processing model. Lockhart, Craik, and Jacoby (1975) suggested that depth be represented as a hierarchy of domains, and that further elaboration of the stimulus could occur within each domain. This within-domain elaboration which has been labelled 'spread of processing' is claimed to facilitate memory. The effects of spread of processing is investigated in this study. In addition, the levels of processing procedure is used to examine the nature of optimal encoding strategies employed in preparation for recall and recognition tests.

Depth and spread of processing

Craik and Lockhart (1972) proposed that the variety of processing operations performed on a stimulus could be conceived of as a continuum proceeding from analysis of physical, or structural, features to analysis of semantic features. The durability of the memory trace produced by these analyses was postulated to be a function of the "depth" of processing: the more semantic (the deeper) the processing, the more durable the trace.

Lockhart et al. (1975) amended this view of depth as a result of objections that physical, phonemic and semantic analyses could not be represented on the same continuum.

Instead they postulated the existence of three distinct domains of processing. The processing domains, physical, phonemic, and semantic, are proposed to be responsible for analyses of qualitatively different features of the stimulus, and are assumed to be hierarchically related. The relative depth of each domain within the hierarchy is the same as that proposed in the original model: physical and semantic domains define the "shallow" and "deep" extremes.

In addition, Lockhart et al. (1975) argued that a stimulus may be subjected to differing degrees of processing, or elaboration, within each of the three domains. They referred to these "additional operations within one qualitatively coherent domain" (p.6) as spread of processing, and predicted that greater spread would result in a richer memory trace and richer information for use at time of retrieval. The degree of elaboration of the stimulus, and the durability of the memory trace, are postulated to be a function of both "the number and nature of the features analysed." Thus both quantitative and qualitative aspects of processing influence memory. This view has been described fully by Craik and Tulving (1975).

In this experiment, to provide a test of the validity of this distinction between depth and spread of processing, two tasks were designed to encourage processing within each of the three domains. One task in each domain was designed to be a _minimal_ processing task, while the second task required more _elaborate_ processing of the stimulus within

that domain. Thus retention performance was compared for tasks both within and between processing domains.

Optimal encoding for recall and recognition

Differences between recall and recognition have been discussed primarily in terms of the number of processes involved in each type of retrieval; hence the dispute between theorists supporting either one-process and two-process models. More recently investigations of the two retrieval modes have been concerned with differences in the nature, rather than the number, of processes involved, and attention has been focussed upon possible differences in control processes utilized by subjects preparing for the different types of test. Differences in strategies used for recall and recognition tests may reflect the differential depth or spread of processing.

For a paired-associate task Freund, Bretsford, and Atkinson (1969) found no differences in recognition performance for material processed in expectation of either recognition or recall tests. Contrary to these results Loftus (1971) suggested that knowledge of type of retrieval affected storage processes, and that these storage differences were partly responsible for performance differences noted between recall and recognition procedures. Loftus found that knowledge of test was most advantageous for recall; the group expecting a recognition test actually performed more poorly on recognition than those subjects

uncertain as to which type of test would follow. This failure to find unequivocal support for the operation of control processes specific to both recall and recognition is typical of a number of other studies.

Carey and Lockhart (1972) found the predicted superiority in recognition for those subjects expecting a recognition test. However, no similar finding emerged in the free-recall data, though recall protocols did indicate different patterns of storage of categorized material for the recall and recognition groups. Jacoby (1973) also failed to find differences in free recall for groups anticapating either recognition, cued recall, or free recall tests. In Jacoby's study knowledge of type of test facilitated performance only for subjects expecting a cued recall test; cued recall apparently encouraged use of a processing strategy optimal for both recall and recognition tests. In Experiment I of Tversky's (1973) study using pictorial stimuli a similar result was obtained. Knowledge of type of test was advantageous for recognition, but not for recall. However, when Tversky provided subjects with both knowledge of type of test and a specific encoding strategy encouraging organization of the list, the group given these instructions produced higher levels of recall than those expecting a recognition test. Griffiths (1975) reported similar results for verbal stimuli and argued for the operation of control processes specific to both recall and recognition processing modes.

Unlike previous studies, the experimental procedures adopted by Tversky (1973) and Griffith (1975) involved the use of explicit encoding strategies assumed to be advantageous to either recall or recognition modes of processing. Griffith instructed subjects to categorize the stimuli, or to use a visual imagery strategy, while Tversky prompted either list organization or feature discrimination. The fact that the clearest evidence for the operation of control processes peculiar to recall or recognition was obtained in these two studies suggests that the provision of knowledge of test-type, on its own, is not sufficient to invoke optimal encoding strategies.

Use of the levels of processing framework offers a number of advantages over procedures used in studies described above, primarily because it serves to place the investigation of control processes into a more systematic theoretical context. Therefore it was proposed to examine the operation of the control processes involved in preparation for recall and recognition testing in relation to tasks within the three processing domains postulated by Lockhart et al. (1975). This would allow an investigation of the relative effectiveness of processing within each domain for either recall or recognition testing. The procedure adopted was similar to that of Carey and Lockhart (1972) except that two control groups were used in addition to the groups which were unexpectedly switched to either recall or recognition following presentation of the final test.

Method

Subjects

The subjects were 95 volunteer students taking introductory Educational Psychology courses at the University of Alberta. Subjects were randomly assigned to one of four treatment conditions and were tested in groups of one to five. The unanalyzed protocols of eight subjects were rejected due to incorrect recording of responses either in the decision or recognition testing phases of the experiment.

Stimuli

Three 60 word lists were chosen from this Toronto word-pool. This word pool contains 1080 common two-syllable words between five and eight letters in length. The lists were equated for total frequency according to the norms of Kucera and Francis (1967). Three other distractor lists, drawn from the same source, were prepared for use in the recognition tests. In these latter lists words were of equivalent frequency to their corresponding target words in the study lists. Distractors for target words were chosen at random, though words with obvious physical, phonemic, or semantic relationships to target words were excluded. The set lists used in the study were all of equivalent total frequency.

Procedure

Subjects were randomly assigned to one of four groups

according to the type of test given following list presentation:

<u>Group</u> <u>RORO</u> completed three recognition (RO) tests;

<u>Group</u> <u>RORA</u> was given two recognition tests and then unexpectedly switched to a recall (RA) test following presentation of the third list.

<u>Group</u> <u>RARA</u> completed three recall (RA) tests.

<u>Group</u> <u>RARO</u> was given recall tests for the first two lists and was then unexpectedly switched to a recognition test for the final list.

Before presentation of the first list subjects were informed that the experiment involved an investigation of perceptual decision-making performance. They were not informed of the retention tests which followed list presentation. Thus the first test for all subjects was presented under incidental learning conditions; Type I incidental learning as described by Postman (1964). Conditions for the final two lists were intentional; subjects were informed that tests of the type used after List 1 would follow presentation of Lists 2 and 3.

On each trial subjects heard a tape-recorded question the offset of which was followed by presentation of a word on a screen for 1 sec. At this point subjects were required

to make a Yes or No response to the question and to record this decision on a prepared sheet. The next trial began with a different question, presentation of a new word, and so on for the 60 words in each list. Subjects were then given a 2 min. filler-task which involved the multiplication of sets of three-digit numbers. Following this the retention tests were administered.

In the recognition conditions, following presentation, subjects received a two-alternative forced-choice (2AFC) recognition test presented at a 4 sec. rate by an overhead projector. Responses for each test item were recorded on prepared sheets. For the recall tests, a free recall procedure was employed, subjects being given 4 min. to recall as many words as they could from the list just presented.

Before presentation of List 3 subjects were informed that they would receive the type of retention test they had completed on the previous two tests. Thus the switch on List 3, for Groups RORA and RARO, was unexpected; in a subsequent questionnaire subjects confirmed that this was the case.

Words were prepared on slides which were projected using a Kodak Carousel projector. External timers controlled the operation of both the projector change mechanism and a shutter which, in turn, controlled slide presentation time. Each trial was initiated by means of a reset switch operated by the experimenter. Total time for a trial, including question, word presentation, and response, was 5 sec. A

pilot study had shown this time to be sufficient for completion of the task.

Questions Prior to projection of a word subjects heard one of six possible types of questions. Following the rationale developed in previous studies (Craik, 1973; Hyde & Jenkins, 1973) the object of these orienting questions was to bias subjects' processing toward one particular level of analysis. In this study, six types of orienting questions were used:

1. Is the word printed in capital letters?
2. Is the following pattern (of consonants and vowels) present: *eg. CVCVC*?
3. Does the word contain the sound: *eg. e*?
4. Does the word contain both the sounds: *eg. a and o*?
5. Is the word a member of the category: *eg. Food*?
6. Is the word a member of both the categories: *eg. Time and Technology*?

(The category labels are included in Appendix 1.1).

Within each list each question type was applied to 10 words, half of the questions for each type encouraging positive responses, half encouraging negative responses.

Question types 1 and 2 were intended to bias processing toward the physical structure of the word, and thus to be tasks representative of those requiring processing primarily within the physical domain. Question 2 was assumed to require more elaborate processing of a word's physical structure than Question 1. This task had been used by Craik and Tulving (1975). Response latency data from that

experiment indicated that the CV-type task took longer to accomplish than Question-type 1.

The tasks chosen for each of the phonemic (Questions 3 and 4) and semantic processing domains (Questions 5 and 6) evinced a more systematic relationship. Type 4 questions required twice the processing load, prima facie, involved in Type 3 questions. Similarly, Type 6 questions required subjects to process words in relation to two categories, compared to the single categorization task involved in Type 5 questions. As indicated above, the purpose of providing two question-types for each domain was to encourage both a minimal, and an elaborate, processing of stimuli within those domains. Evidence provided by this minimal-elaborate comparison was relevant to the spread and depth of processing hypotheses.

Subjects were given practice on a set of 24 question-word-decision trials, involving four trials for each of the question types. Following completion of practice, presentation of the study tests began. The order of presentation of the three lists was randomized. In addition, two question x word orders were prepared for each list, each list-order being presented to half the subjects within each of the four treatment conditions. The three word lists are included in Appendix 1.2.

Results

The recall and recognition results are reported separately for domains, for the comparison of minimal and elaborate processing within each domain, and for Yes and No responses at each of the levels within each domain. The domain analysis is the most general. It involves collapsing Yes/No response data and data from the two levels within each domain. This analysis serves to relate the overall results of the study to the levels of processing model. The results for minimal and elaborate levels of processing within each domain constitute one of the major questions of the study-depth vs spread of processing. The most detailed analysis is concerned with retention of words given either Yes or No responses during list presentation. Recall and recognition results were analysed separately.

Depth of processing: between-domain processing

Recognition

2AFC recognition scores (hits) for the two recognition groups are given in Table I-1: scores represent percentage correct recognition.

The results suggest that for the domains unit of analysis, the recognition performance of subjects in this study is generally similar to that predicted by the levels of processing model, and found in previous studies using the

Table I-1

Percentage correct recognition as a function of processing Domain: Recognition groups, Lists 1 and 2.

	List 1			List 2		
GROUP	PHYSICAL	PHONEMIC	SEMANTIC	PHYSICAL	PHONEMIC	SEMANTIC
RORO (n=21)	67.8	76.6	93.3	70.1	76.1	94.5
RORA (n=23)	65.7	75.1	93.6	69.7	76.4	93.7

paradigm (Craik, 1973; Craik & Tulving, 1975). Recognition performance improves as subjects move from physical to phonemic to semantic processing tasks, in both groups and on both lists. This interpretation was confirmed by analyses of variance of percentage correct recognition which showed a significant main effect for domain for both groups on both lists: for Group RORO $F(2,40)=79.88$, $p<.01$; for Group RORA $F(2,44)=81.66$, $p<.01$. Individual comparisons between means, using the Newman-Keuls procedure (Winer, 1962, p. 309) indicated that recognition following semantic tasks was clearly superior to that following tasks in the physical or phonemic domains. However the difference between means for the physical and phonemic domains was not significant(see Appendixes 2.5 and 2.6). Summary tables for both analyses are included in Appendixes 2.1 and 2.2.

In general, the recognition performance across domains follows the pattern predicted by the levels of processing model, though the difference in level of performance for physical and phonemic tasks is less than expected.

Recall

Recall scores for the two recall groups are given in Table I-2. Scores are expressed as percentage correct recall.

Table I-2

Percentage correct recall as a function of processing Domain: Recall groups Lists 1 and 2

	List 1			List 2		
GROUP	PHYSICAL	PHONEMIC	SEMANTIC	PHYSICAL	PHONEMIC	SEMANTIC
RARA (n=23)	4.3	2.7	20.9	9.6	6.0	23.1
RARO (n=28)	5.8	3.3	25.8	8.8	6.8	28.7

The level of recall for both groups on both lists was quite low, and at least for recall following physical and phonemic tasks probably represents a 'basement' effect. Similar levels of recall have been reported by Schulman (1974) and by Craik and Tulving (1975). The latter authors raised recall levels by presenting half of their list items twice. Due to the need to have comparable conditions for recognition and for recall groups such a manipulation was not possible in this study.

The recall results do not follow the pattern predicted by the levels of processing model; increased depth of processing, going from physical to phonemic tasks, does not necessarily result in higher levels of recall. However the very low absolute level of recall performance for these tasks suggests that these findings should not be the basis for serious criticism of the model. Semantic processing tasks resulted in a relatively good recall. Analyses of variance of recall percentages (see Appendixes 2-3 and 2-4) indicated that for both groups the main effect for domain was highly significant: for Group RARA $\underline{F}(2,44)=60.39$, $p<.01$; Group RARO $\underline{F}(2,54)=79.39$, $p<.01$. This effect was due primarily to the clear superiority of recall following semantic tasks over that following any other task.

For both recall groups, recall under intentional conditions (List 2) was significantly better than in the incidental conditions (List 1). The main effect for List in the ANOVA for both groups was significant: Group RARA $\underline{F}$

(1,22)=11.19, p<.01; Group RARO $\underline{F}(1,27)=5.72$, $p<.01$.

The recall results follow those obtained in other research on levels of processing (Craik & Tulving, 1975; Experiment 3). Recall following the deepest levels of processing, in the semantic domain, is clearly superior to that in either of the domains. However the low level of performance on these latter tasks, indicates that the free recall paradigm in this study did not provide a good test of the levels of processing model.

Summary: depth of processing-between domains

The importance of depth of processing for both recognition and recall is apparent in the general pattern of recognition performance in this study, although the precise levels of recognition across physical and phonemic domains predicted by the model are not present. Recall for tasks requiring greatest depth of processing is clearly superior to that for other tasks; other recall results are too low to allow evaluation of the validity of the model in any more detail.

Spread of processing: elaboration within domains

Recognition

Results for the two recognition groups on both minimal and elaborate processing tasks are shown in Table I-3. As is apparent in the domain results recognition performance improves from physical to phonemic to semantic tasks, with

the semantic tasks resulting in highest level of recognition.

The predicted facilitation of performance by further elaboration with a domain is not apparent in any consistent manner. Only within the semantic tasks is there improved recognition performance following elaborate tasks. Within the physical and phonemic domains, recognition following the elaborate tasks is generally poorer than that following the minimal processing tasks. Analyses of variance indicated that in both recognition groups there was no significant main effect for elaboration: Group RORO $\underline{F}(1,20)=1.98$, $p>.25$; Group RORA $\underline{F}(1,22)=1.09$, $p>.25$.

Although the Domain x Elaboration interaction was significant for both groups (Group RORO $\underline{F}(2,40)=3.46$, $p<.05$; Group RORA $\underline{F}(2,44)=4.14$, $p<.025$) the interactions are not of major theoretical significance. In both interactions, diagrammed in Figures I-1 and I-2, any facilitation due to spread is present only in the semantic tasks. The interaction for the RORO Group (Fig. I-5) is primarily due to the low level of recognition on the elaborate task within the physical domain.

The recognition results provide little support for the spread hypothesis. Apart from the small degree of

Table I-3

Percentage correct recognition as a function of elaboration within domains. Recognition groups: Lists 1 and 2.

	List 1						List 2					
GROUP	PHYSICAL		PHONEMIC		SEMANTIC		PHYSICAL		PHONEMIC		SEMANTIC	
	M	E	M	E	M	E	M	E	M	E	M	E
ROFD (n=21)	72.9	64.7	74.5	78.8	94.2	92.6	74.7	65.5	79.9	72.3	93.2	95.9
ROFA (n=23)	64.8	66.7	75.7	74.4	89.9	97.5	70.8	68.6	78.0	74.7	93.8	96.5

Note: M = minimual processing task

E = elaborate processing task

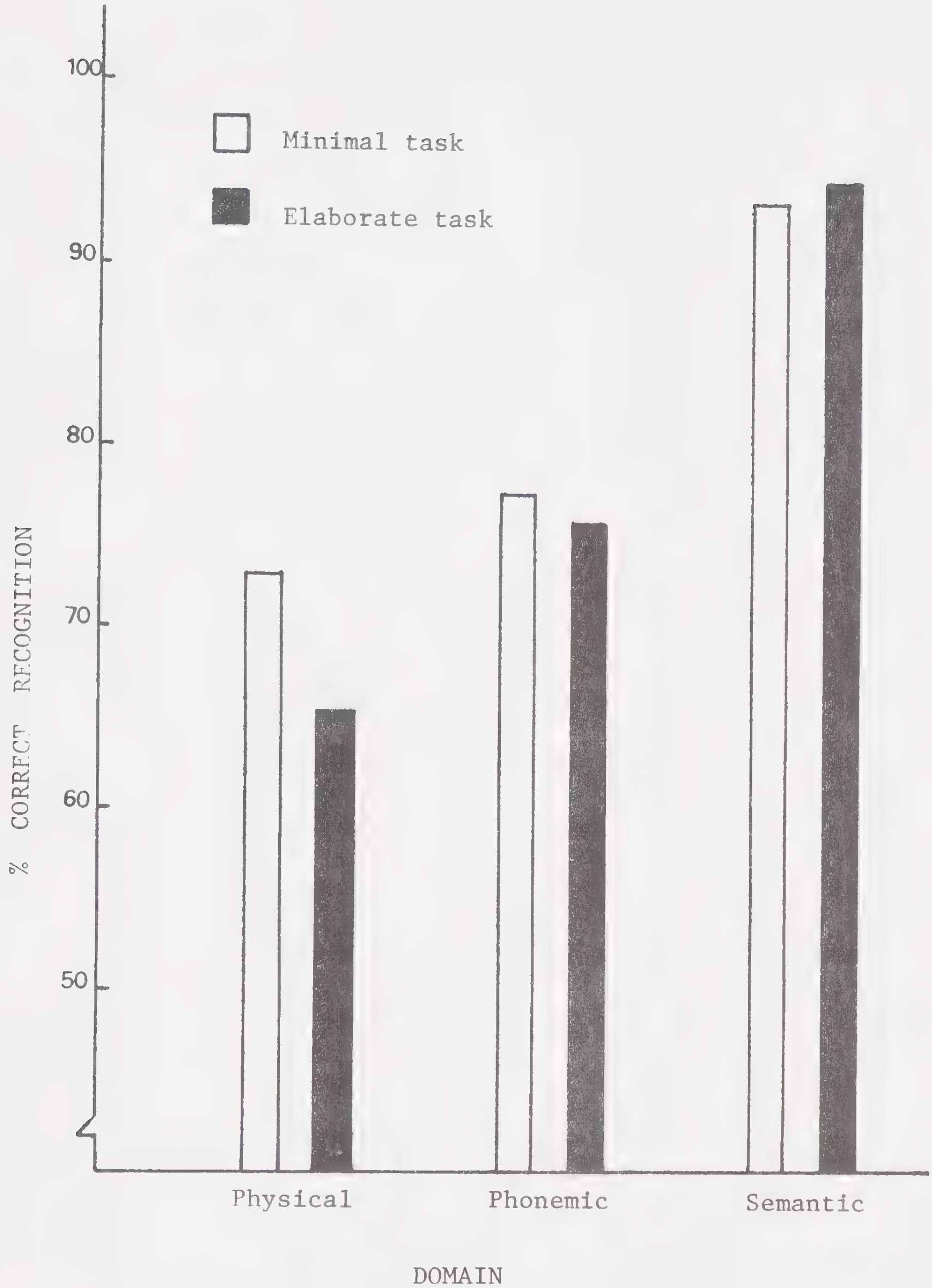

FIGURE I-1. Diagram of Domain x Elaboration interaction: Group RORO, Lists 1 and 2.

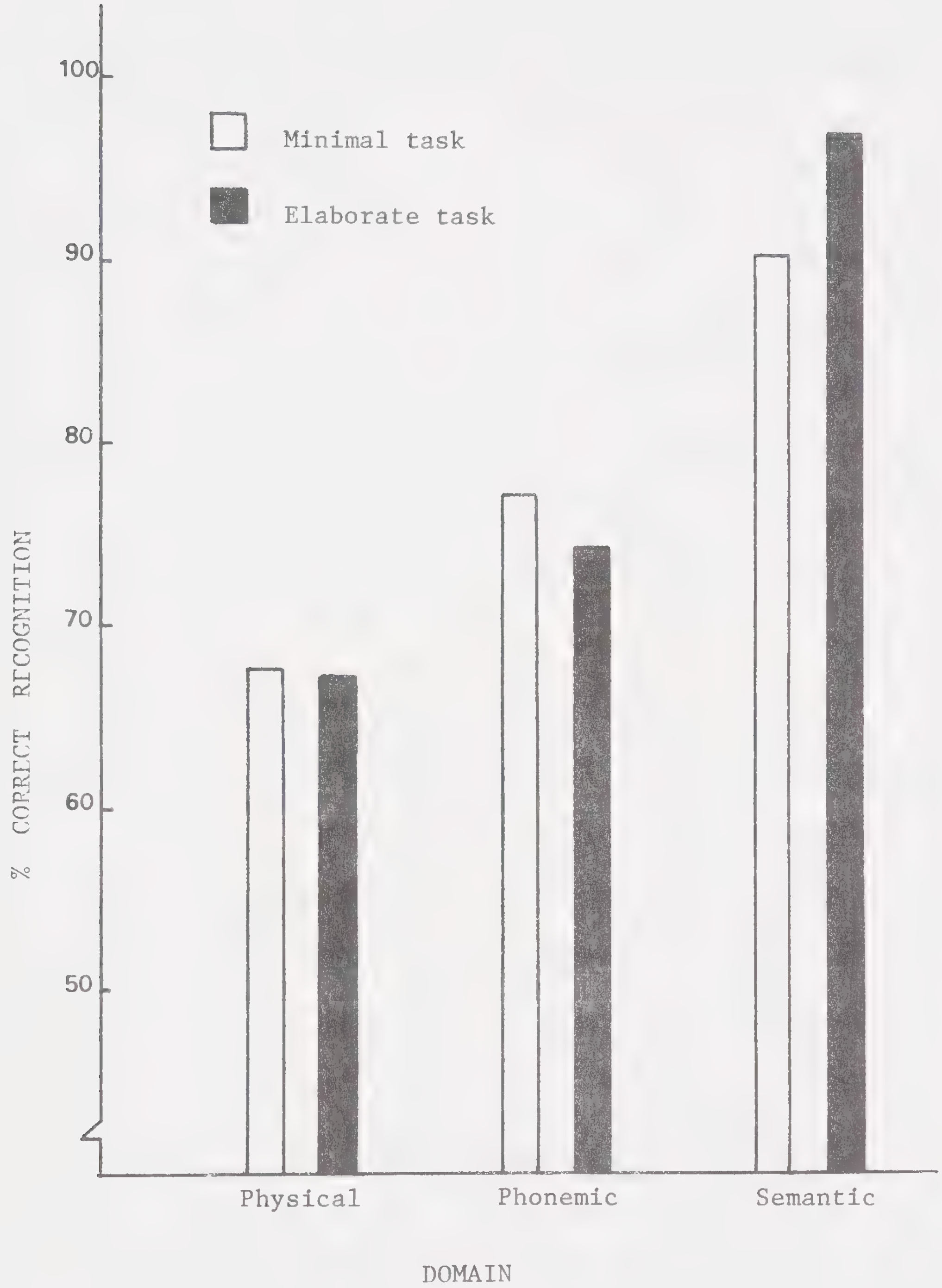

FIGURE I-2. Diagram of Domain x Elaboration interaction: Group RORA, Lists 1 and 2.

facilitation of recognition accompanying elaborate processing within the semantic domain, elaborate tasks were no more beneficial for recognition than were the minimal processing tasks.

Recall

Results for free recall following the shallow and elaborate tasks are given in Table I-4. The degree of elaboration makes little difference to subsequent recall for these physical and phonemic tasks, although the low levels of recall may mask real differences between these conditions.

In the case of the semantic processing tasks a consistent pattern is evident: elaborate processing results in better recall for both recall groups on both lists. (The same pattern is also present in the recall results for the RORA group on List 3, when that group was switched unexpectedly from recognition to recall). The superiority of elaborate over minimal task recall was mainly responsible for the significant main effect for elaboration present in the analyses of variance for both the recall groups: Group RARA $\underline{F}(1,22)=16.20$, $p<.01$; Group RARO $\underline{F}(1,27=10.80$, $p<.01$. The Domain x Elaboration interactions were also significant: Group RARA $\underline{F}(2,44)=5.52$, $p<.01$; Group RARO $\underline{F}(2,54)= 11.64$, $p<.01$. These interactions are diagrammed in Figures I-3 and I-4. Inspection of these figures indicates that the

Table T-4

Percentage correct recall as a function of elaboration within domains: Recall groups, Lists 1 and 2.

	List 1						List 2					
GROUP	PHYSICAL		PHONEMIC		SEMANTIC		PHYSICAL		PHONEMIC		SEMANTIC	
	M	E	M	E	M	E	M	E	M	E	M	E
BAPA (n=23)	1.7	6.9	1.2	4.2	13.8	28.0	9.5	9.7	6.9	5.0	18.4	27.9
BARO (n=28)	4.6	7.6	2.9	3.7	10.4	32.3	7.9	9.6	7.0	6.7	21.9	35.5

Note: M = Minimal processing

E = Elaborate processing

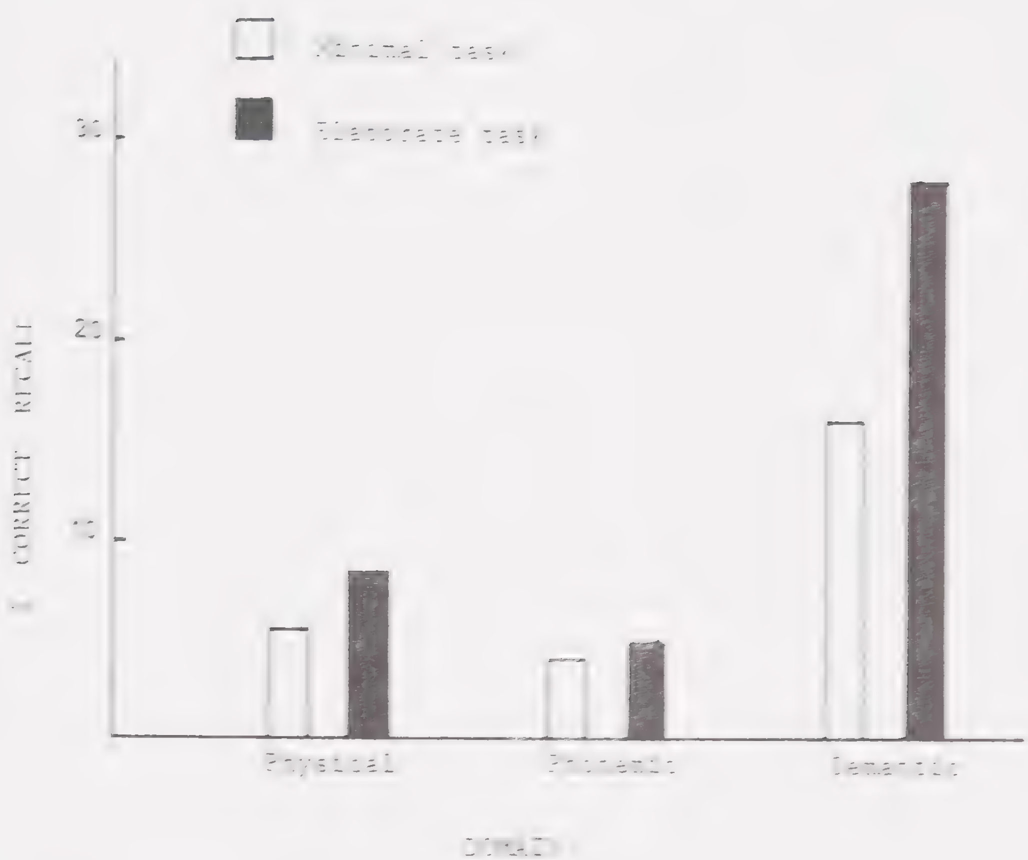

FIGURE 3-7. Diagram of Domain x Elaboration Interaction:
Group RARA, Lists 1 and 2

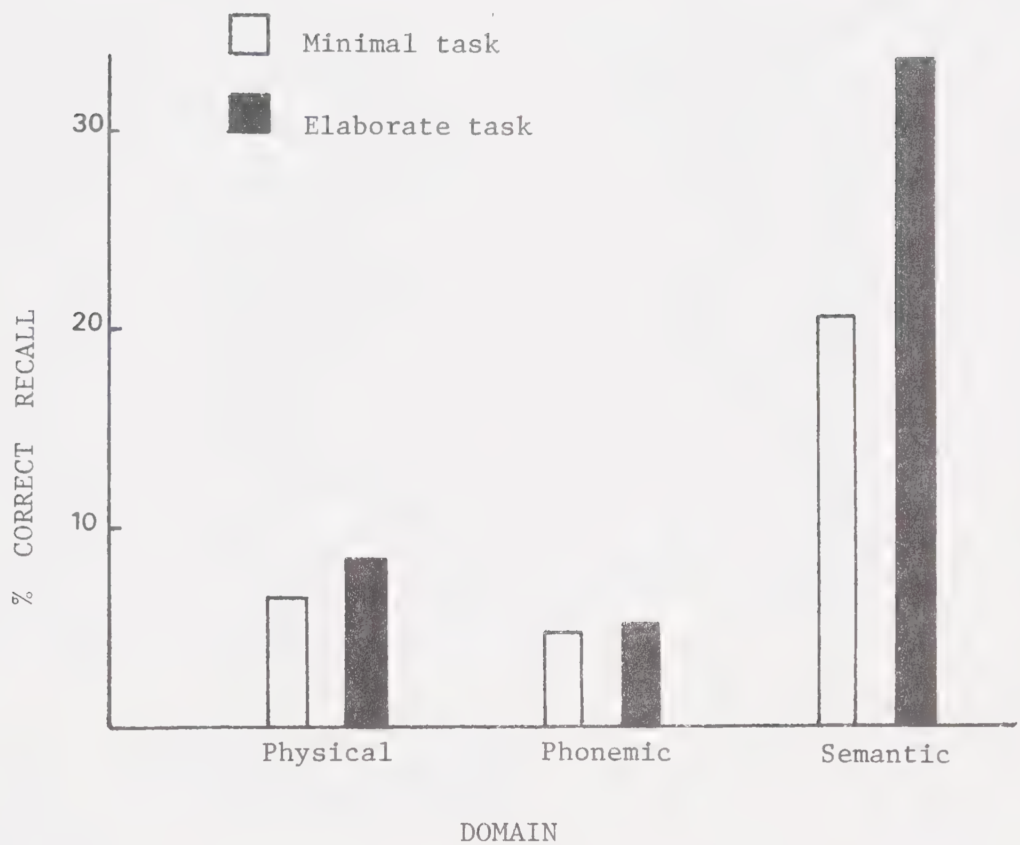

FIGURE I-4. Diagram of Domain x Elaboration interaction: Group RARO, Lists 1 and 2.

superiority of elaborate over minimal processing in the semantic tasks provides the main strength of the interaction.

Summary: spread of processing-elaboration within domains

The major evidence for the predicted facilitation accompanying spread of processing comes from the recall performance on semantic tasks. For the semantic domain, elaboration results in better recall than that which follows the minimal processing task. While the same pattern is present in the recognition, results the effect of elaboration for performance on that type of test is not significant. Thus, the spread hypothesis proposed by Lockhart et al. (1975) is supported only by the recall results for semantic tasks.

Positive and Negative responses

Recognition

Results for the recognition groups when response type is considered are given in Table I-5. The pattern of performance is similar to that for elaboration. Within the physical and phonemic domains there is no consistent pattern relating positive and negative responses, while for semantic tasks recognition following Yes responses is generally better than for words given No responses. Analyses of variance for both recognition groups (see Appendixes 2.1 and

2.2) showed no significant main effect for response type; nor were any of the interactions involving response type significant in either group. These results do not replicate those obtained by Craik and Tulving (1975; Experiment 2) in which words given Yes responses were recognized more often than those given negative responses, at least for phonemic and semantic tasks. Craik and Tulving interpret these performance differences in terms of differences in encoding, arguing that Yes responses yield richer encodings. As will be discussed later, the implications are that in this experiment the Yes and No responses did not result in differential encodings.

Recall

The parallel set of results for recall groups are given in Table I-6. As was the case for recognition groups, the pattern of performance following Yes and No responses shows no consistent pattern. However in the semantic tasks, words given positive responses are better recalled than those for which the response was negative. Analyses of variance showed that the main effect for response type was significant for

Table I-5

Recognition Groups. Percentage correct recognition as a function of response type: Lists 1 and 2.

List 1

	PHYSICAL				PHONETIC				SEMANTIC			
	MINIMAL		ELABORATE		MINIMAL		ELABORATE		MINIMAL		ELABORATE	
GROUP	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
RORO (n=21)	68.3	73.6	63.3	66.1	74.4	74.5	76.7	80.9	97.9	90.0	95.4	89.7
RORA (n=23)	61.7	67.8	67.2	66.1	77.5	73.9	79.0	69.8	93.9	85.8	98.0	96.9

List 2

RORO	70.4	79.0	68.3	62.7	78.1	81.6	77.0	67.5	94.3	92.0	95.9	95.9
RORA	69.5	72.1	69.9	67.3	76.5	79.6	80.2	69.1	91.0	90.7	96.8	96.3

Table I-6

Recall Groups: Percentage correct recall as a function of Response Type: Lists 1 and 2.

	PHYSICAL				PHONEMIC				SEMANTIC			
	MINIMAL		ELABORATE		MINIMAL		ELABORATE		MINIMAL		ELABORATE	
GROUP	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
					List 1							
FAFA (n=23)	3.4		7.2	6.6	[illegible].9	1.4	1.6	6.8	15.2	12.3	35.6	20.4
RAFO (n=28)	2.1	7.1	7.9	[illegible]	5.1	[illegible].7	3.1	4.3	27.6	11.2	35.6	28.9
					List 2							
FAFA	9.9	9.2	8.5	10.9	8.0	5.7	2.8	7.2	25.3	11.4	31.9	23.8
RARO	12.4	3.6	7.3	11.9	6.3	7.7	4.4	8.9	28.2	15.7	46.3	24.7

the RARO group only: $\underline{F}(1,27)=17.31$, $p<.01$. The Domain x Response type interaction was highly significant for both groups: Group RARA $\underline{F}(2,44)=9.03$, $p<.01$; Group RARO $\underline{F}(2,54)=20.42$, $p<.01$. As depicted in Figures I-5 and I-6 the clear superiority of recall for positive over negative decisions provides the main strength in both interactions. The relationship between positive and negative decisions in recall found in this experiment is similar to that reported previously by Schulman (1974) and Craik and Tulving (1975).

Summary: positive and negative responses

The rationale for separate consideration of positive and negative decisions is primarily empirical. As Schulman (1974) and Craik and Tulving (1975) have shown, there is a consistent superiority in performance following positive decisions, at least for tasks involving semantic processing. This finding is replicated here for recall, and to a lesser extent for recognition. No similar consistent effect is apparent for any of the other tasks.

Optimal encoding: performance on List 3

Recognition

Results for groups given recognition tests on the final list are given in Table I-7. Inspection of these figures indicates that there is no consistent superiority of performance associated with the group anticipating a recognition test. In fact, the group which was preparing for

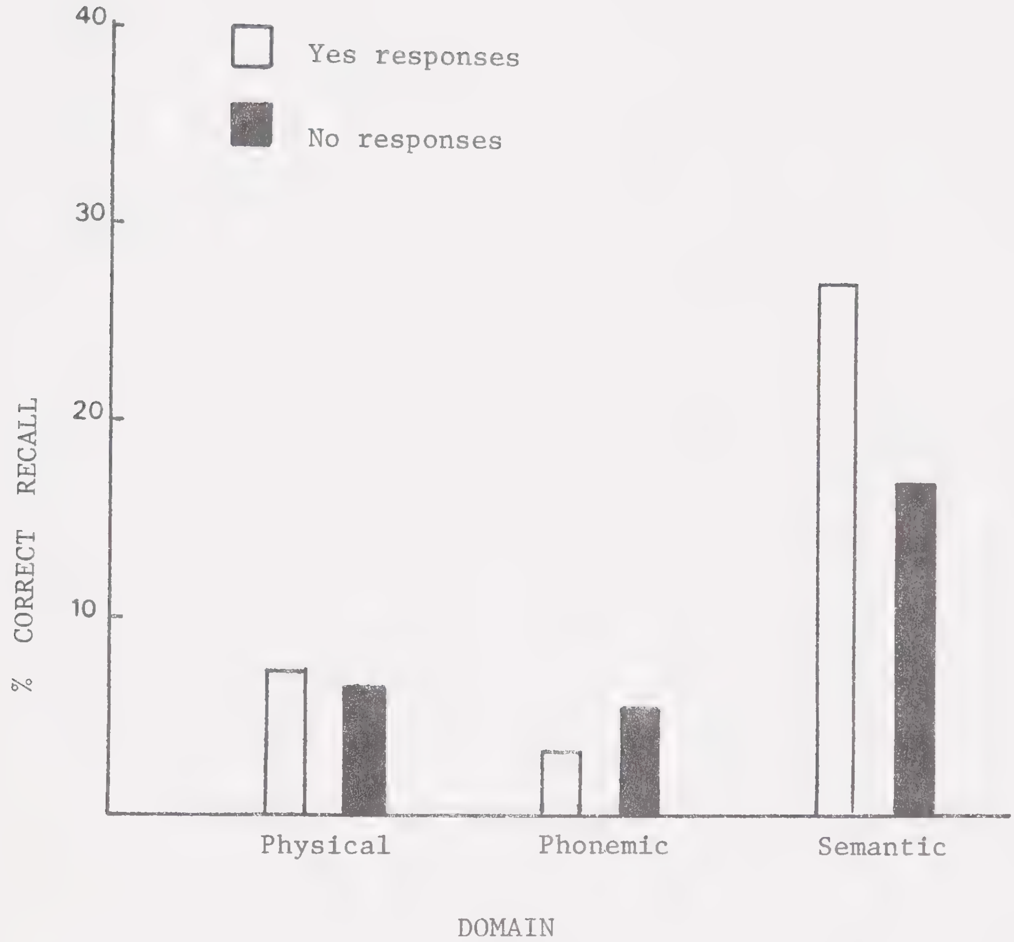

FIGURE I-5. Diagram of Domain x Response Type interaction: Group RARA, Lists 1 and 2.

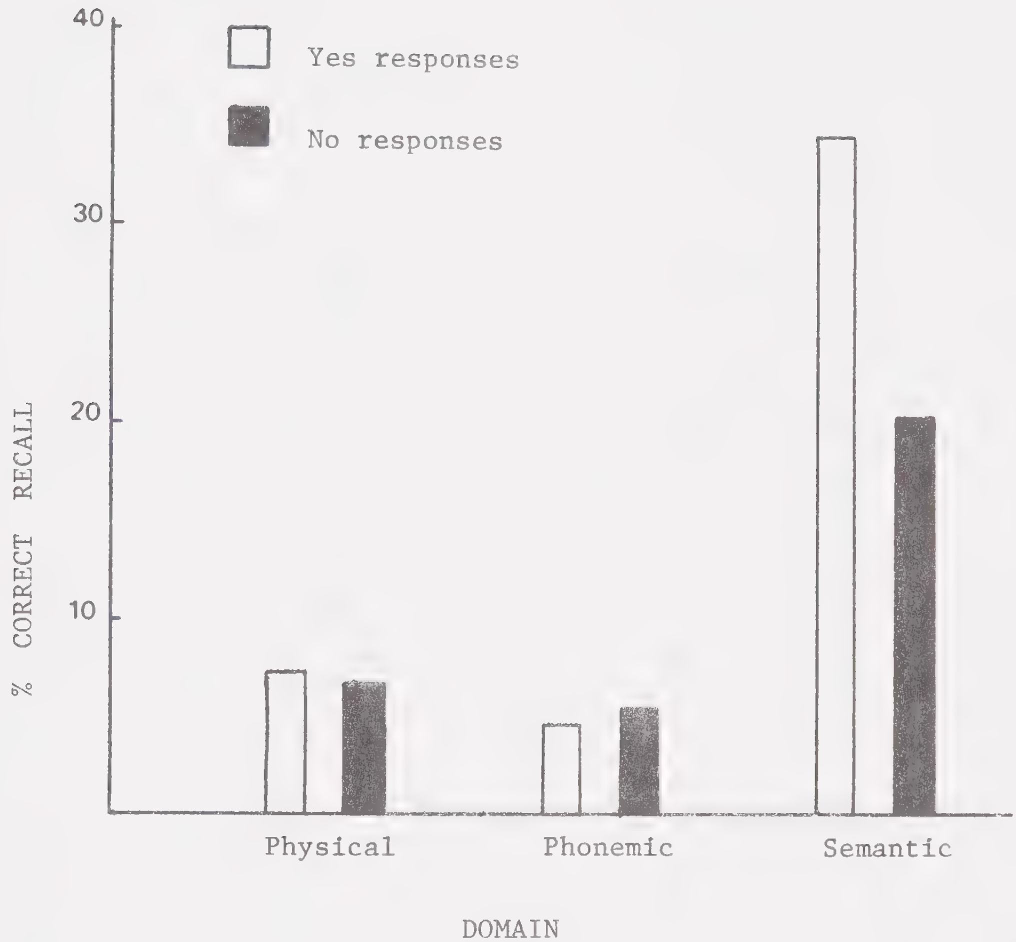

FIGURE I-6. Diagram of Domain x Response Type interaction: Group RARO, Lists 1 lnd 2.

a recall test did somewhat better on both physical and phonemic tasks. Analysis of variance for percentage correct recognition showed that there was no main effect for test expectation: $\underline{F}(1,47)=0.92$, $p>.3$. Thus, the prediction that knowledge of test would lead to better recognition performance is not supported by these results.

Main effects for domain and for response type were both significant: $\underline{F}(2,94)=58.57$, $p<.001$; $\underline{F}(1,47)=10.53$, $p<.01$. The main effect for domains reflected a higher level of recall for words processed semantically than for words given either physical or phonemic processing. Means for the physical, phonemic and semantic domains respectively were, 73.1%, 73.1% and 90.8%. Words given a positive response were recognized more frequently than those for which the response was negative, the respective means being 81.1% and 76.9%.

In the ANOVA two interactions were significant. The Domain x Response Type interaction ($F(2,94)=3.59$, $p<.05$) is diagrammed in Figure I-7. The superior recognition for words given Yes responses in phonemic and semantic domains is absent in the physical tasks. This result is similar to those obtained by Craik and Tulving (1975). The types of

Table I-7

Recognition performance on List 3 as a function of Response Type and Test Expectation

	PHYSICAL				PHONEMIC				SEMANTIC			
	MINIMAL		ELABORATE		MINIMAL		ELABORATE		MINIMAL		ELABORATE	
GROUP	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
EXPECTED TEST (FORC (n=21)	68.6	73.3	78.7	69.0	68.4	68.6	71.3	67.4	96.9	83.2	98.3	88.9
UNEXPECTED TEST RARC (n=28)	78.5	74.3	66.3	75.8	81.2	70.0	77.6	76.2	91.8	89.9	94.2	84.2

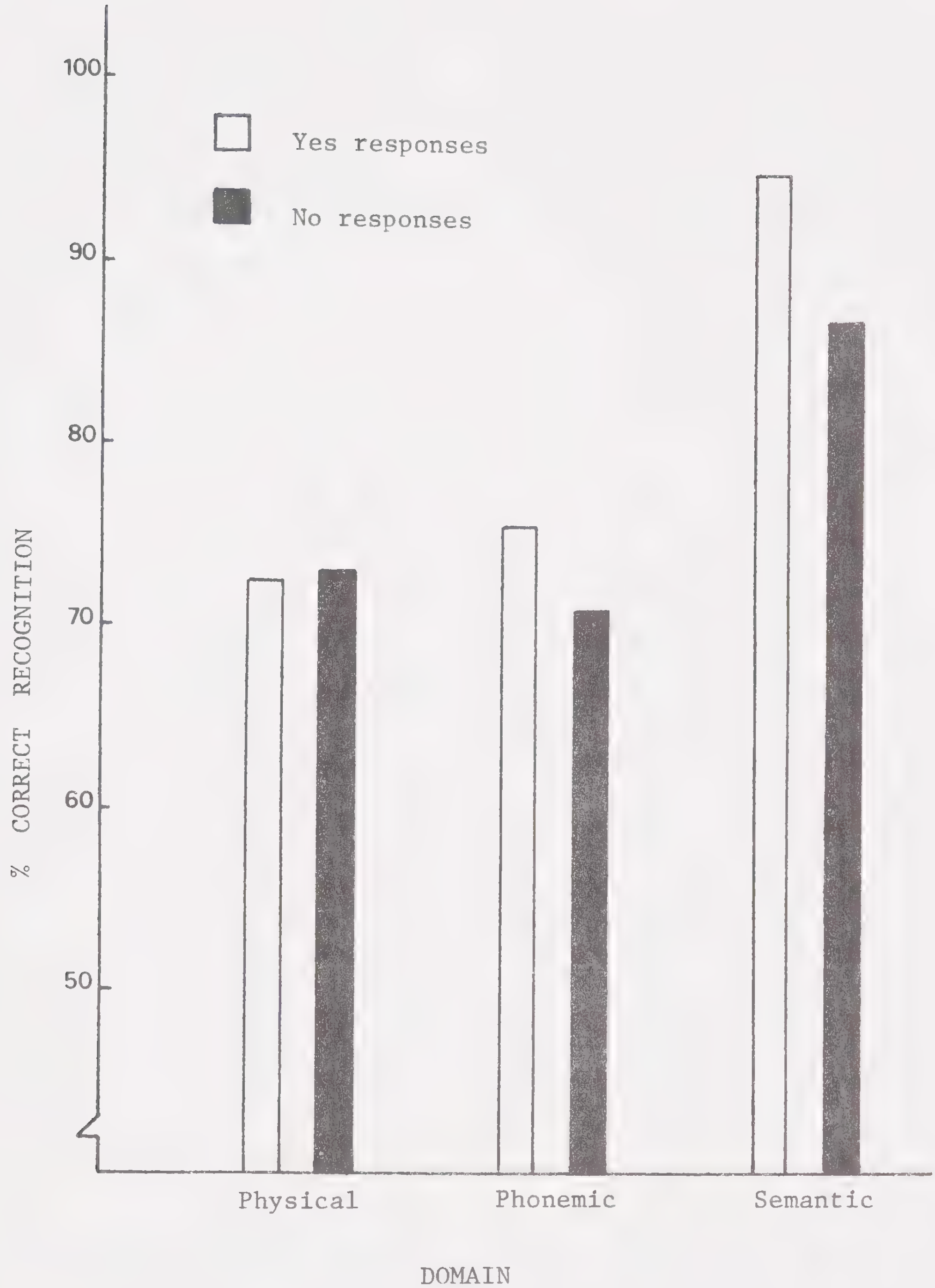

FIGURE I-7. Diagram of Domain x Response Type interaction: Recognition groups, List 3.

response made to the physical tasks apparently do not result in differences in richness, or uniqueness, of encoding.

Interpretation of this interaction is made difficult by the presence of a significant 4-way interaction-Expectation x Domain x Elaboration x Response type $\underline{F}(2,94)=3.69$, $p<.03$. The complexity of this interaction as depicted in Figure I-8 makes it largely uninterpretable. While the pattern of performace for the two groups is similar for the No responses one major point of discrepancy is apparent for Yes responses. For the physical tasks the groups perform in opposite fashions. The group correctly anticipating a recognition test performed better on elaborate tasks than on those given minimal processing. For the group expecting a recall test the opposite is true. Elaboration facilitates performance of those preparing for recognition; but did not do so for those subjects expecting recall. Speculatively, this might represent a difference in processing for recall and recognition tests. However the reliability of the effect of elaboration is uncertain, especially since it was not apparent for the RORO group on the first two lists (see Fig. I-1).

The single major difference in level of recognition performance between the two groups is that for phonemic tasks, on which the group expecting recall performed better on both minimal and elaborate processing tasks than did the group anticipating a recognition test. This difference in level was not sufficient to provide a significant

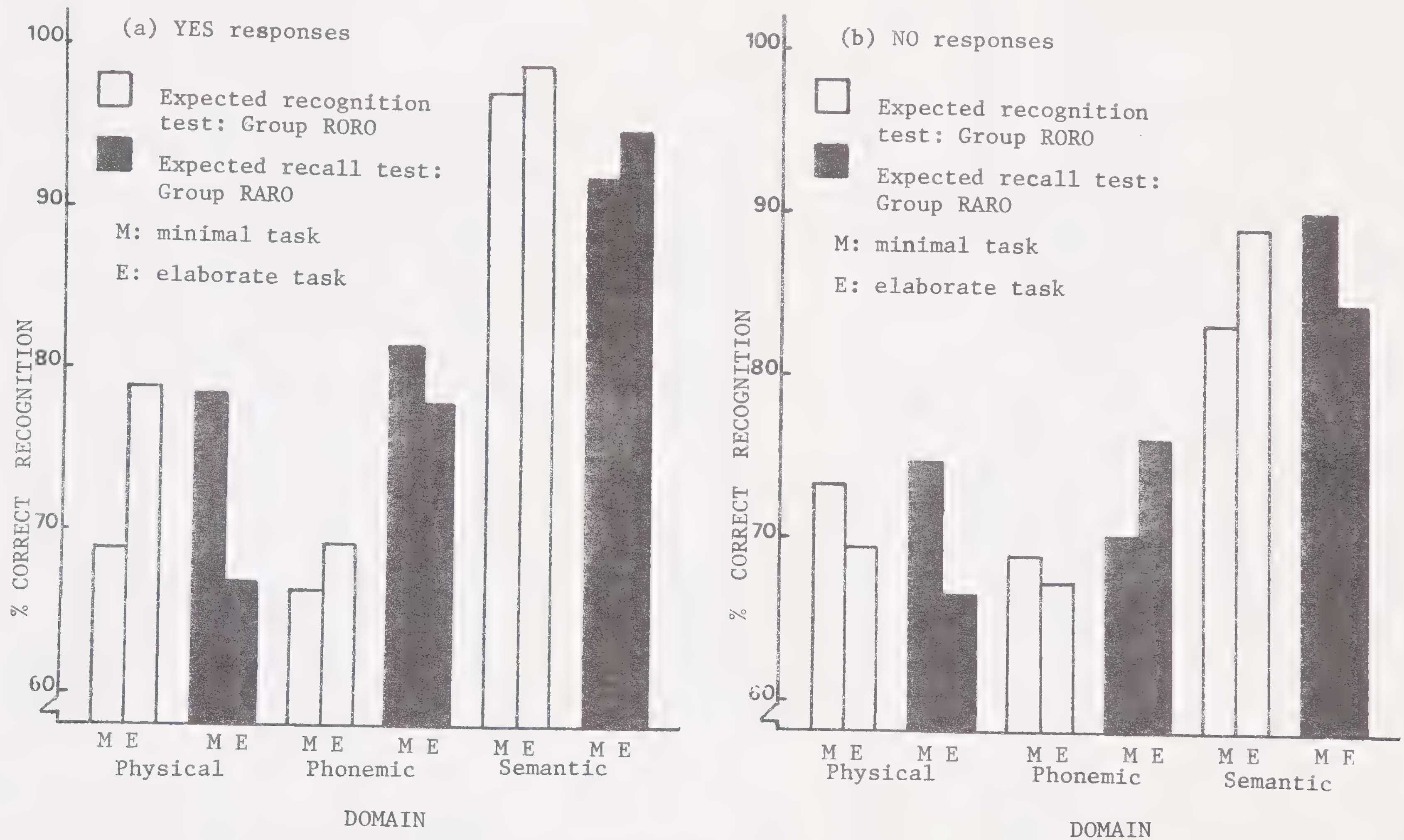

FIGURE I-8. Diagram of Expectation x Domain x Elaboration x Response Type interaction: Recognition groups, List 3.

Expectation x Domain interaction ($\underline{F}(2,94)=2.97$, $p<.10$), though the difference in means is substantial.

Recall

Results for recall performance on List 3 are given in Table I-8. From the Table it is apparent that the subjects preparing for recall perform better following physical and phonemic tasks than do those anticipating recognition testing. As in previous recall results the low level of performance may mask any real differences between these groups.

On the semantic tasks the level of recall is similar for the two groups, with those subjects preparing for recognition recalling more of the words given elaborate processing.

Analysis of variance of the recall results (see Appendix 3.2) indicated that the main effect for expectation was not significant: $\underline{F}(1,44)=1.30$, $p>.25$. As in the case of recognition performance, the predicted advantage accompanying knowledge of test was not apparent for recall.

Table I-8

Recall performance on List 3 as a function of Response Type and Test Expectation

GROUP	PHYSICAL MINIMAL YES	PHYSICAL MINIMAL NO	PHYSICAL ELABORATE YES	PHYSICAL ELABORATE NO	PHONEMIC MINIMAL YES	PHONEMIC MINIMAL NO	PHONEMIC ELABORATE YES	PHONEMIC ELABORATE NO	SEMANTIC MINIMAL YES	SEMANTIC MINIMAL NO	SEMANTIC ELABORATE YES	SEMANTIC ELABORATE NO
EXPECTED TEST												
RAFA (n=23)	12.6	11.9	11.4	12.7	5.1	7.4	8.8	4.0	24.6	8.5	29.7	16.1
UNEXPECTED TEST												
RORA (n=23)	4.3	3.5	6.3	9.9	4.2	2.6	1.5	2.0	20.7	12.9	44.6	14.0

All other main effects were significant for the recall performance on List 3. For domains ($\underline{F}(2,88)=70.55$, $p<.001$) this effect reflected the dominance of semantic processing over other types of task in its effect on subsequent recall; the mean percentage recall for the physical, phonemic, and semantic domains were 9.1%, 4.4%, and 21.4% respectively. Elaborate processing tasks resulted in better mean recall (13.4% vs 9.9%) than did minimal processing tasks: $\underline{F}(1,44)=10.94$, $p<.01$. Words given Yes responses were better recalled than those given No responses: $\underline{F}(1,44)=23.84$, $p<.001$. The mean percentage recall for Yes and No responses was 14.5% and 8.8%.

The recall results for List 3 followed the pattern seen in Lists 1 and 2, with semantic tasks, elaborate processing, and Yes responses resulting in highest levels of recall.

Several interactions were significant in the analysis of variance. The Expectation x Domain interaction ($\underline{F}(2,88)=5.57$, $p<.01$) is diagrammed in Figure I-9. For physical and phonemic tasks knowledge of the recall test is an advantage; the group preparing for recall out preforms the group expecting a recognition test. This advantage is not so important for the semantic tasks. On these tasks the nature of processing undertaken appears to offset any advantage given by foreknowledge of test type. This interpretation should however be regarded as tentative in light of the low level of recall for physical and phonemic processing. It is apparent from Figure I-10 that this

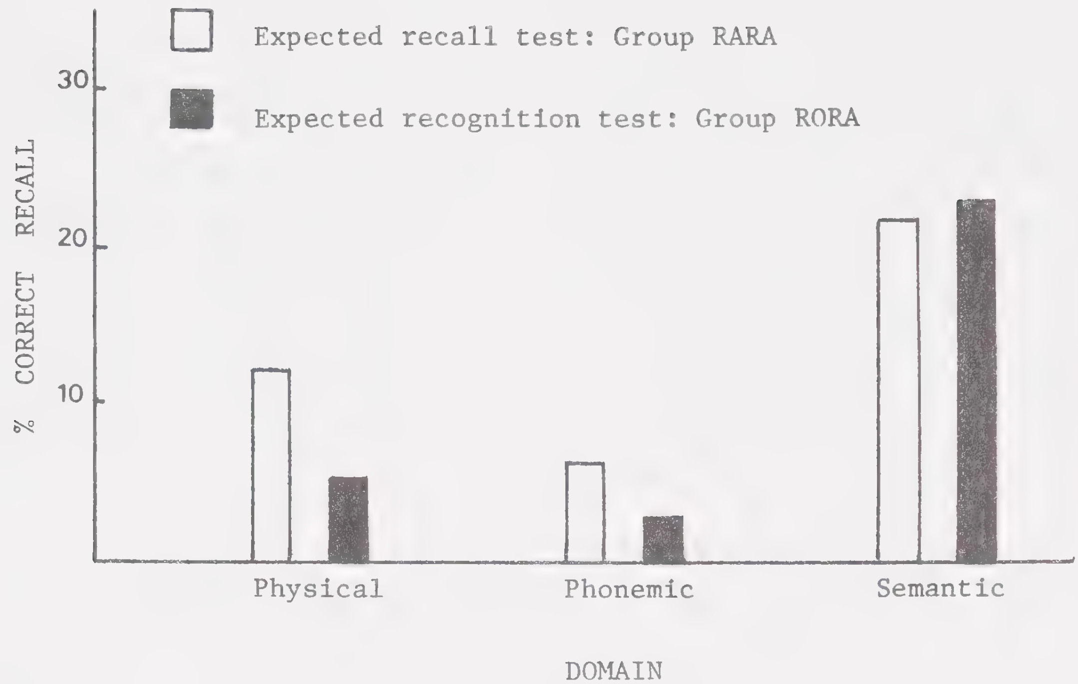

FIGURE I-9. Diagram of Expectation x Domain interaction: Recall groups, List 3.

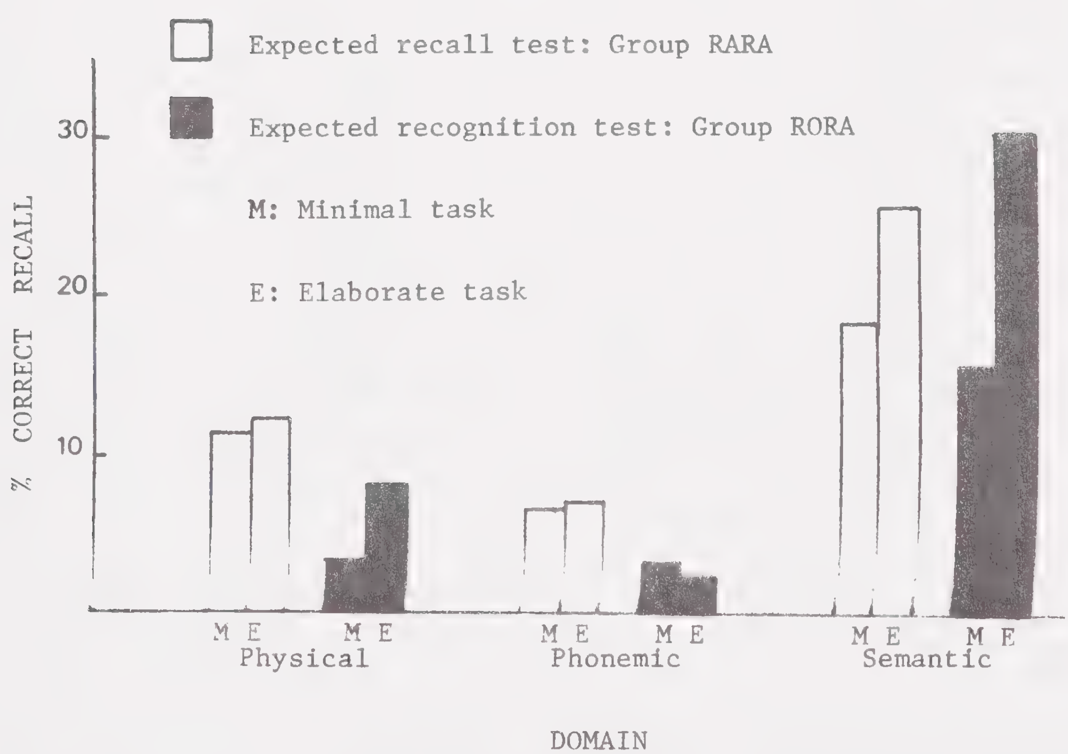

FIGURE I-10. Diagram of Expectation x Elaboration interaction: Recall groups, List 3.

interaction of domain and expectation was relatively similar for both minimal and elaborate processing tasks. The Expectation x Elaboration interaction, diagrammed in Figure I-10, is significant: $\underline{F}(2,88)=8.52$, $p<.001$. Thus, (with a reservation about level of performance) it appears that for recall, knowledge of test may be most important for more shallow processing; deeper, semantic, levels of processing appear to compensate for the lack of knowledge about type of test.

The Domain x Elaboration interaction, diagrammed in Figure I-11, is also significant: $\underline{F}(2,88)=8.52$, $p<.001$, and reflects the large degree of facilitation of recall brought about by elaborate processing within the semantic domain. This result is similar to that noted for the recall groups on Lists 1 and 2. An almost identical pattern of results is responsible for the significant Domain x Response Type interaction shown in Figure I-12: $\underline{F}(2,88)=24.97$, $p<.001$. Mean recall for words given Yes responses is clearly superior to that for No responses for semantic tasks. With the exception of the Expectation x Domain interaction, the two-way interactions follow the patterns discussed in recall results on Lists 1 and 2, with the mian effects of elaboration and positive responses being localized to semantic tasks.

Two complex interactions were also significant. From the diagram of the Domain x Elaboration x Response Type interaction in Figure I-13, it appears that the facilitation

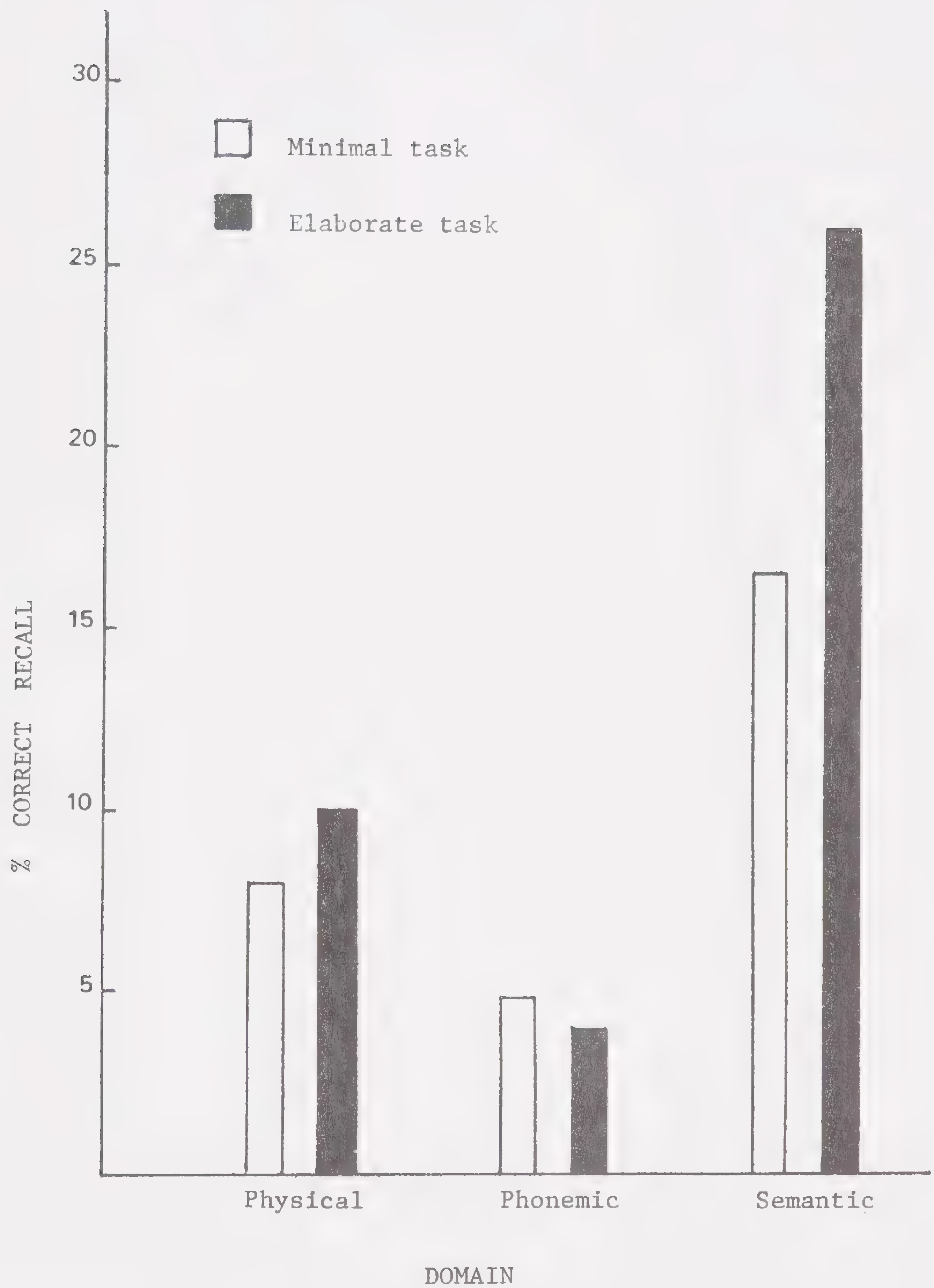

FIGURE I-11. Diagram of Domain x Elaboration interaction: Recall groups, List 3.

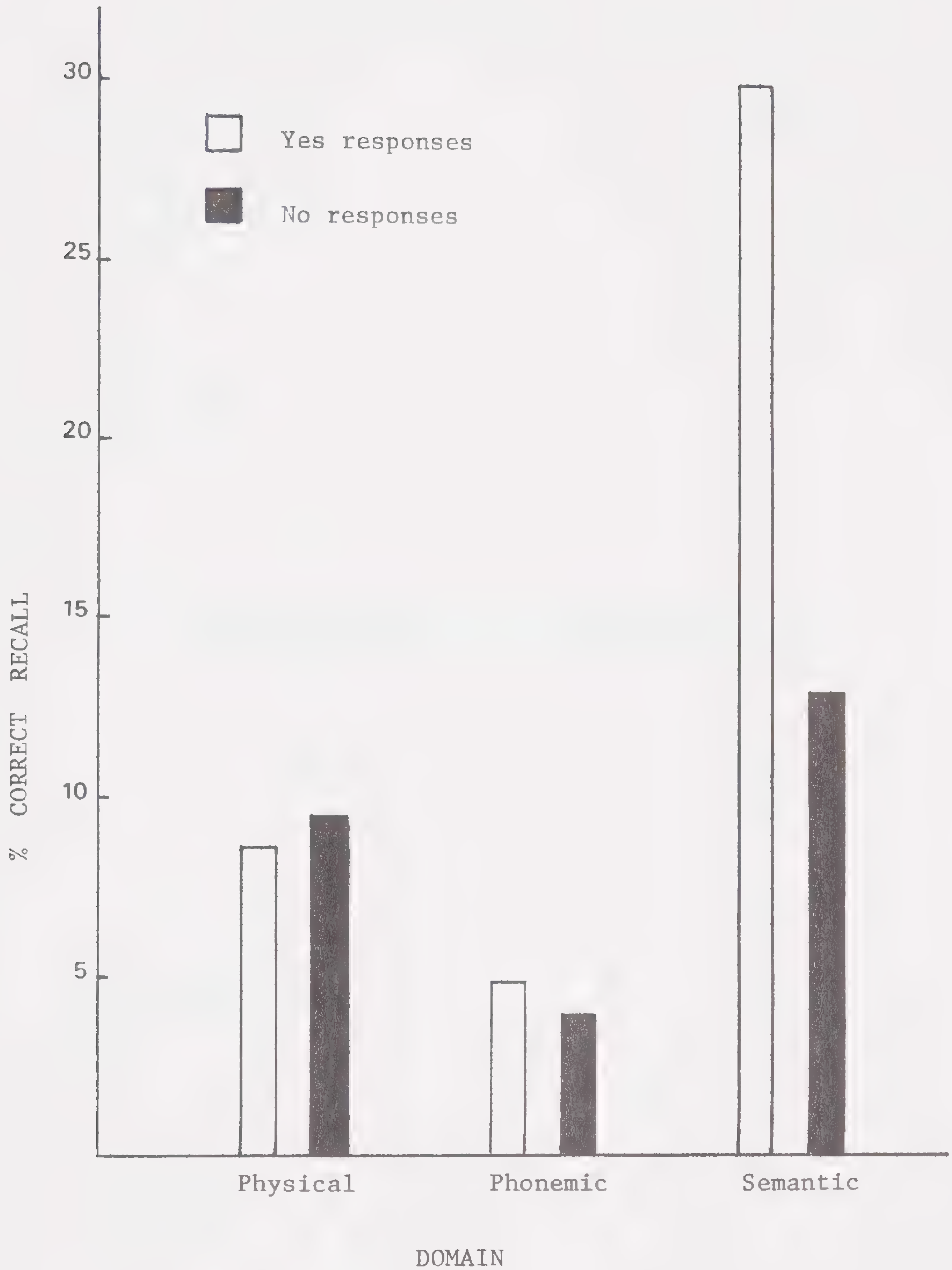

FIGURE I-12. Diagram of Domain x Response Type interaction: Recall groups, List 3.

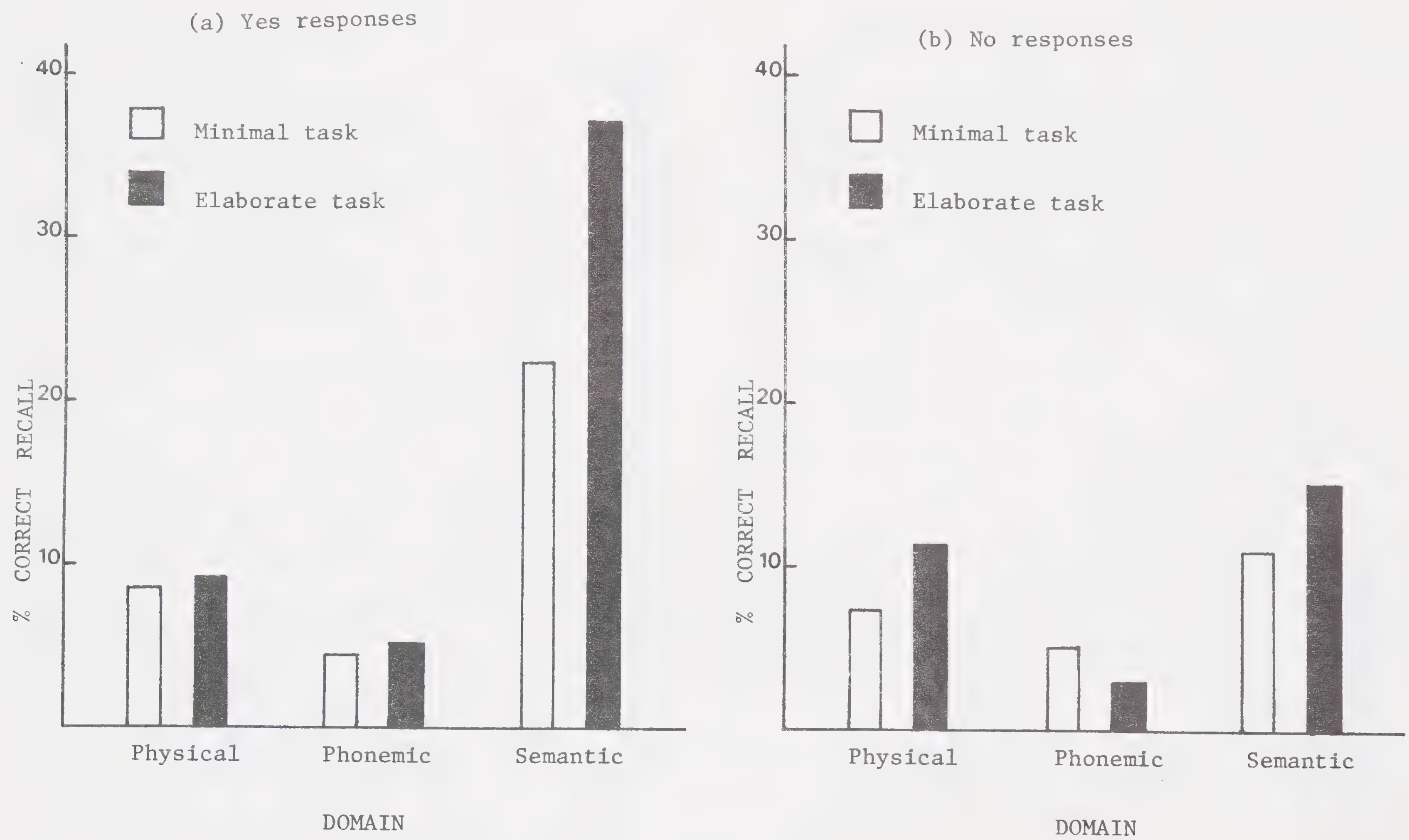

FIGURE I-13. Diagram of Domain x Elaboration x Response Type interaction: Recall groups, List 3.

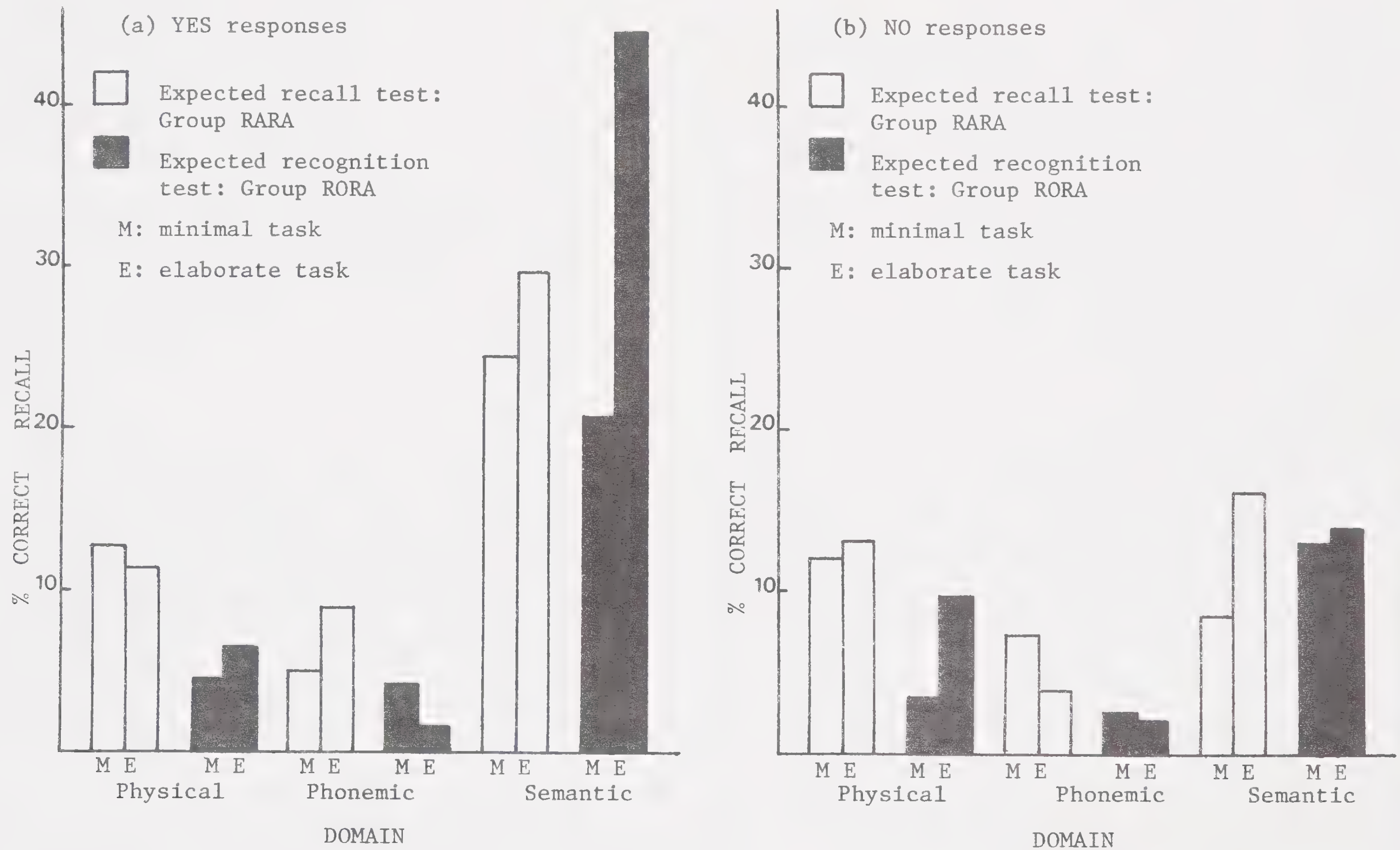

FIGURE I-14. Diagram of Expectation x Domain x Elaboration x Response Type interaction: Recall groups, List 3.

due to elaboration occurs largely for positive responses. For negative responses the effect of elaboration is much reduced. This result gives support to Craik and Tulving's (1975) argument that the effect of a positive response may be to "specify the event more uniquely." (p. 282). It is also of interest (see Figure I-14) that the effect of elaboration and positive response is most advantageous to the group which was expecting a recognition test. In light of this it appears that recognition processing _is_ affected by organization in the storage phase of processing. The interaction diagrammed in Figure I-14 is that for Expectation x Domain x Elaboration x Response Type: $F(2,88)=6.99$, $p<.01$.

Summary: Optimal encoding-performance on List 3

The results for free recall testing following List 3 generally follow the pattern observed for Lists 1 and 2; recall is best following semantic tasks, and especially good for words given elaborate semantic processing and positive responses. Potentially, the most important result from this aspect of the experiment is the Expectation x Domain interaction which suggests that knowledge of type of test is an advantage at shallow levels of processing, though not for deeper more semantic processing. The complex interactions discussed in the last section above are also interesting. They suggest that the effects of elaboration and positive response are to some extent additive for semantic tasks. Also of significance was the fact that the group most

effected by elaboration and positive response type and semantic tasks was the group preparing for a recognition test.

Recognition results also followed patterns discussed in results for Lists 1 and 2. No overall advantage of knowledge of test was evident; this was also the case for recall. In this last respect the results here do not replicate those of Carey and Lockhart (1973) Tversky (1973) or Griffith (1975).

Incidental and intentional learning

Levels of performance under incidental instructions (List 1) and intentional instructions (List 2) show that while there was no difference in level of recognition between the two conditions, intentional recall was better than incidental recall. These results were confirmed by analyses of variance which indicated no significant main effect for List in recognition groups: $F(1,20)=0.5$, $F(1,22)=0.7$. For both recall groups the List main effect was significant: Group RARA $F(1,22)=11.9$, $p<.01$; Group RARO $F(1,27)=5.72$, $p<.01$. The facilitation of recall on List 2 was present for all tasks; there were no significant List x Elaboration interactions.

These results follow closely those reported by Estes and DaPolito (1967). Craik and Tulving (1975) Experiment 4 also report intentional-incidental differences in recall. However, these two studies are used (or not used) to argue for different perspectives on recall and recognition. Estes

and DaPolito (1967) use their results as the basis for a two-process theory of recall and recognition, implicating a search or retrieval process in recall which is not present in recognition. Craik and Tulving (1975) favor an interpretation in which recall and recognition are functionally equivalent. It must be noted that despite Craik and Tulving's claim that "what determines the level of recall or recognition is not intention to learn. . ." (1975, p.290), it is clear from their own data, and in the results discussed here, that intention to recall does have a facilitative effect.

Discussion

Depth of processing

In general the recall and recognition results give only equivocal support to the distinctions between qualitatively different processing domains proposed by Lockhart et al. (1975). The present recognition results follow the pattern predicted by the levels of processing model, although there is no consistent superiority of performance on phonemic as opposed to physical tasks. In recall, while semantic processing is clearly most advantageous, differences in performance following physical and phonemic processing are minimal. With respect to recall, the low levels of performance in this and other similar studies (Schulman, 1974; Craik & Tulving, 1975) imply that the free recall procedure may not be sufficiently sensitive to provide evidence of differences in nature of the memory trace. This

problem has recently been discussed by Tulving and Bower (1974) and also by Watkins and Tulving (1975). It is apparent the main advantage of free recall, the 'freedom' it gives to the subject, may be a disadvantage when the nature of encoding-storage is under investigation.

The effects of instructions to recall also raise a minor problem for those like Craik and Tulving (1975) who give intention to learn only minimal attention, despite experimental findings which argue to the contrary. When subjects are aware that they will be required to recall the words at a later time, their processing strategies result in a level of performance which is higher than when they are not forewarned of the recall test. This line of argument may suggest that recall and recognition are being separated in a manner similar to that suggested by Kintsch (1970), and that a two-process view of recall is being argued for.

However a two-process view of recognition and recall based on an extra retrieval stage being present in recall, though not in recognition, is not a necessary corollary of the intentional-incidental results in recall. The issue of retrieval in recognition is quite distinct from that raised here, and, as will be argued later, the evidence for retrieval in recognition is more impressive now than when reviewed by Mc Cormack (1972).

Rather, it might be more relevant to consider the effect of intention still within the levels of processing framework. If this is done, the effect of intention to

recall is an extra dimension to the processing being carried out on the stimulus event, and can be likened to the "modes of processing" discussed by Carey and Lockhart (1973), for that is what the intentional recall condition amounts to. Hence, intention to recall may well result in greater spread of processing. Such a position could be tentatively supported by the results obtained on List 3 recall in this study which showed superior performance on shallow tasks for those subjects preparing for a recall test (see Figure I-9). Such a difference is not apparent in recognition.

Thus the notion of depth of processing is heuristically fruitful, though doubts may be raised about certain specific predictions which have been derived from the original hypothesis that depth influenced durability. In this study, while the general sense of the depth hypothesis is supported, it is also seen as a potentially useful framework for consideration of the factor of intention to remember. Assigning an effect to intention does not necessarily invalidate the position that it is the "... kind of operations carried out on the items, that determines retention." (Craik & Tulving, 1975 p.290). Rather, intention to remember should be seen as just such a "kind of operation", though one which might have an effect over and above certain types of orienting tasks.

Spread of processing: elaboration within domains

The results of this study give only qualified support

to the notion that further processing within a domain results in better retention. For the physical and phonemic domains the effects of further stimulus elaboration are minor; in some cases the more elaborate processing resulted in lower levels of performance than did the minimal processing task. The major support for the spread hypothesis is found in the recall findings for the semantic tasks, and to a limited extent in the recognition performance on the same tasks. Hence, the facilitative effect of spread of processing is manifested for only one group of tasks.

The semantic tasks in this experiment involved categorization of words. The spread of processing effect amounts to the fact that words processed in relation to two categories were recalled, and to a lesser extent recognized, more often than words related to a single category. Spread of processing is not the only explanation of such an effect.

It is possible that the use of two category labels results in something akin to the encoding variability effect explored by Madigan (1969) and Melton (1967). According to this hypothesis, the provision of the second category would provide for greater variation in the encoding of the item and thus greater storage of information about the item, which would result in higher probability of recall.

The results could also reflect the effect of subjects' use of cues at time of retrieval. Category labels were presented as part of the orienting questions for the semantic tasks, and although no explicit cues were presented

at time of recall subjects may have used the category labels as self-generated cues when asked to recall or recognize. (Several subjects reported use of such a strategy in a post-experiment questionnaire). If this cue-utilization at time of retrieval did occur, the results for the elaborate tasks should be similar to those obtained in multiple-cueing studies. Findings from these studies (e.g. McLeod, Williams, & Broadbent, 1971; Solso, 1974) indicate that the use of multiple cues does result in improved recall. Solso (1974) suggests that the effect results from generation on implicit associative responses (IARS) to the cues.

Though both of the above explanations appear as plausible alternative explanations of the effect of elaboration, each is also compatible with a spread of processing interpretation. The differential encoding, or encoding variability hypothesis is in fact quite close in nature to the idea of spread of processing, for both hypothetical processes serve to make the memory trace more unique.

In the multiple-cueing study by McLeod et al. (1971) it is clear that cues by themselves do not result in generation of the stimulus word, but that cues associatively related to the stimulus word do produce relatively high levels of recall. It appears that the original encoding of the word is made more unique, or salient, by the categorization task. If subjects did in fact use category labels as cues at time of retrieval, these more unique traces would be more likely to

be associated with any IARS. Thus, it is possible to maintain the spread hypothesis, though other explanations may be more explicit in providing suggestions as to why spread has the effects claimed for it. It is also clear that such a construct cannot be solely concerned with conditions at time of encoding-storage; the retrieval environment must also be considered.

In terms of the present experiment, it is possible to argue that the tasks used failed to bring about elaboration within the physical and phonemic domains. While this is a reasonable criticism it is not all that helpful. In a quantitative sense the tasks used here can be defended as being representative of minimal and elaborate processing demands; each elaborate task required more processing than the corresponding minimal processing task. Since spread of processing is essentially a quantitative elaboration, as opposed to a qualitative elaboration (in the description by Lockhart et al. 1975), the tasks used appear to have at least content validity for their minimal and elaborate titles.

A more fruitful criticism of the procedure used in this study is concerned with the nature of the retrieval tests used. As mentioned previously in the case of the free recall test, the retrieval tests may not have been sufficiently sensitive to detect differences in degree of elaboration of the stimulus. As has been argued by Tulving and Bower (1974), both types of test used here may not provide

detailed information about the nature of the memory trace.

In the recognition procedure no attempt was made to relate target items and their lures on any basis except frequency. For a particular word the test did not provide evidence which would allow the inference that the nature of the memory trace was biassed toward physical, or phonemic, or semantic features of the stimulus. A more fine-grained approach would involve the use of a constrained recognition procedure in which target items and lures would be related in a clearly defined fashion. Thus if the test involved target words and their synonyms the most difficult items should be those which subjects have processed semantically. (The results of the Anisfeld and Knapp (1968) study support such a view.) It could then be reasonably inferred that the initial encoding had been semantic. Such an argument could be extended to cover the case where different degrees of semantic elaboration were involved. A similarly constrained recall procedure based upon sequential presentation of various cues at time of retrieval has been proposed by Watkins and Tulving (1975) as a means of increasing the sensitivity of the free recall procedure.

Prior to the present Experiment, Craik and Tulving (1975) reported one study (Experiment 7) which involved recall and cued recall tests following sentence completion tasks. Present evidence for the construct, therefore, is limited largely to semantic tasks followed by recall data. Thus, the notion of spread of processing must be seen as one

supported by rather meagre evidence at present. Certain other explanations can account for the effects claimed for elaboration within domains. Further investigations of the construct may need to employ more sensitive measures of retrieval.

Positive and negative responses

The rationale for differentiation between positive and negative responses is also based upon the idea of stimulus elaboration. Craik and Tulving (1975) propose that positive responses are likely to result in more elaborate processing of the stimulus than negative responses, in the sense that the memory trace for the former will be more 'unique' or 'coherent.' This argument is based upon the notion of congruity of encoding proposed by Schulman (1974). In Schulman's terms the advantage of the positive, or congruous, response is derived from the fact that in such a situation the question and the stimulus-word are given a relational encoding; in the case of a negative response no such encoding is formed.

There is no consistent superiority of retention for words given Yes responses over those given negative responses in this study. In recall, the effect is clearly evident for semantic tasks, though not for physical or phonemic tasks. In recognition, the results are similar though the facilitation of recognition for words given Yes responses is present to a lesser extent.

It is in the analysis of results for List 3 that the strongest effects of response type are evident. In both recognition (see Fig. I-14), and recall (see Figures I-13, I-14), there are clear differences in patterns of performance for semantic processing. In recognition the level of performance for positive responses is higher than that for negative responses, and it is possible that the differences are attenuated by a possible ceiling effect for positive response data. The difference in pattern of performance is more pronounced in the recall results.

Recall following semantic processing of words given positive responses is at a much higher level than for corresponding tasks in which words were given negative responses. It appears that the effect of positive response and elaboration is cumulative. With respect to this result, an explanation in terms of congruity of encoding makes good sense. At least for semantic processing tasks, response type should be considered in analysis of data.

On the basis of this conclusion it would appear that the questions used in the physical and phonemic domains did not encourage major differences in encoding for the two response types.

Optimal encoding

The results reported here do not show the predicted advantage of knowledge of type of test for either recall or

recognition. Close examination of the studies reviewed previously shows that, in the case of recall, the present results are not unique. Carey and Lockhart (1973), Jacoby (1974), Griffith (1975) and Tversky (1973) all failed to find this main effect for expectation, though Tversky (1973) and Griffith (1975) were able to elicit the effect by providing explicit coding strategies for subjects. Comeau (Note 1) has found a superiority for groups expecting recall over those given the test unexpectedly in recent studies.

However, the recall results provide one potentially important effect, that associated with the Expectation x Domain interaction (see Fig. I-9). This interaction suggests that knowledge of test is important up to a point, and that such knowledge is less important the deeper, or more semantic the processing. As argued previously knowledge of test is not sufficient to produce facilitation of recall. If these results prove reliable, the provision of strategies other than the ones which encourage organization may also facilitate performance when subjects know that they will be given a recall test.

It has been argued above that this result may have important implications for consideration of differences found in intentional and incidental recall situations. Intention to learn may be seen as an intention to use a particular processing strategy or control process. For this reason the intentional learning condition, and the utilization of an optimal processing strategy in preparation

for recall testing, are functionally equivalent.

It is interesting to note that in their study of semantic and acoustic coding, Jacoby and Goolkasian (1973) found a pattern of results similar to that depicted in Figure I-9. In their study, no incidental-intentional recall differences were present for the semantic coding task, but on acoustic tasks intentional recall was superior to that in an incidental learning condition.

Neither recall nor recognition results support the view proposed by Underwood (1969; 1972) that different types of attributes would be differentially influential in recognition and recall. On the basis of Underwood's view, physical and phonemic attributes may have been expected to be more important in recognition than in recall, and semantic (associative) processing more important in recall than recognition. Neither prediction is confirmed by these results. Contrary to Underwood's view, the group preparing for recall performed better on phonemic tasks in both recall and recognition. However, it is unclear as to why phonemic processing should be optimal for free recall.

Performance on semantic tasks argues strongly against the view that recognition is not affected by organization. Indeed, the majority of evidence provided by studies using the levels of processing procedures has shown the important effect which organization has on both recall and recognition. The results of List 3 performance indicate that subjects preparing for recognition in this procedure are

able to utilize organization to an extent equivalent to those preparing for recall. Such a finding argues against the conclusion of Griffith (1975) that orienting tasks fostering organization are optimal for free-recall. The effect of organization on recognition in this study also argues against the position of Kintsch (1970) that organization has little or no effect on recognition, although the present results address an issue which was not considered by Kintsch. Kintsch argued that organization had no effect on recognition because recognition did not involve retrieval. However, as pointed out by McCormack (1972), recognition can also be influenced by organization in encoding-storage, irrespective of the issue of retrieval. From the results of this experiment it appears that preparation for recognition involves organization during encoding-storage. Hence, the two-process view of Kintsch (1970) may still be viable, if not for the reasons he proposed.

Summary of discussion

The most important aspects of the present results may be summarized as follows:

1. There is equivolcal support for the distinctions between qualitatively different domains.
2. Intention to recall has an effect which appears to be most important at shallow levels of processing. Such a finding can usefully be accommodated by the levels of processing model.

3. The evidence for facilitation of performance due to spread of processing is limited to performance on semantic tasks. At present the investigation of effects of both depth and spread may be handicapped by lack of sensitivity of retention tests.
4. Evidence for congruity of encoding is limited to semantic tasks. On these tasks the cumulative effect of elaborate processing and positive responses is strongest.
5. There was no overall facilitation of recall or recognition due to knowledge of test type. There is some evidence for optimal encoding in recall, for physical and phonemic tasks, and in recognition, for phonemic tasks only.
6. Recognition is influenced by organization during storage and this is reflected in performance on both recall and recognition tests.

For the levels of processing model, point 1 above is of crucial importance. While the proposal that depth of processing influences durability of memory is supported by the results, the definition of depth in terms of qualitatively distinct processing domains is not. For this reason the distinction between domains was examined more closely in Experiment II. A more powerful test of the domain hypothesis was designed involving a more complex physical processing task and a change in the nature of the recognition test as discussed above. The general purpose of these changes in procedure was to test a strong version of

the domain hypothesis described in Craik and Tulving (1975). One further aspect of Experiment II examined the proposal that differences in retention following the different orienting tasks reflected differences in processing load or effort involved in carrying out those tasks.

EXPERIMENT II

The results of Experiment I raised two doubts about the validity of Lockhart, Craik, and Jacoby's (1975) description of depth of processing in terms of domains. First, the distinctions held to exist between domains did not emerge clearly in performance data. In addition, it was apparent that tasks used to represent the physical domain did not require subjects to process the complete stimulus event. Both of these factors may have diminished the power of the procedure used on Experiment I as a test of the domain hypothesis. Therefore, this hypothesis was tested directly in Experiment II. The tasks used in this study were modified, as a result of the experience in Experiment I, and a different recognition test was adopted. In addition evidence was gathered relevant to the degree of effort involved in each of the different processing tasks.

Depth of processing and the retrieval environment

In postulating the existence of qualitatively different processing domains Lockhart, Craik and Jacoby (1975) set down a 'strong' version of the levels of processing view of memory. The 'strength' in this line of argument lies in the critical predictions which can be derived from its central postulate. Craik and Tulving (1975) made just such a critical prediction in discussion of their most recent

experiments:

> . . . it should be borne in mind that retention depends critically on the qualitative nature of the encoding operations performed--a minimal semantic analysis is more benefical for memory than an elaborate structural analysis. (p.291).

On the basis of their own data such a claim would seem to find good support, at least for recognition tests of memory. However, in Experiment I, while the recognition results were generally supportive of this above position, they were not unequivocally so. The recall results in that study, and in Craik and Tulving's (1975) own Experiment 3, do not show any differences in level of performance between tasks in physical and phonemic domains. Thus some doubts are raised about the above domain hypothesis. Furthermore the results of studies involving highly practiced physical processing (Kolers, 1975) argue for the powerful effects of some types of physical analysis on subsequent memory.

In discussion of the procedure employed in Experiment I dissatisfaction was expressed with the physical tasks employed. Neither of those tasks required consistent processing of the complete word-stimulus. The decision about upper or lower case could be taken on the basis of the first letter of the word, and several subjects reported that the consonant-vowel question could sometimes be answered by reference to less than the complete word. Since similar criticisms are applicable to physical tasks used by other investigations of levels of processing it seemed important to employ a physical task which necessitated that subjects

process the complete word-stimulus. In other words a more complex physical processing task was required--complex in the sense that it was more varied or subtle, rather than being more time consuming. In this study the task for the physical domain required subjects to check words for spelling errors.

While it was hypothesized that use of the spelling task should operate to facilitate retention for words processed in the physical domain, one further measure was adopted to increase the power of the test made on the prediction by Craik and Tulving. This involved biassing the recognition test against semantic processing, by making the recognition test harder for words processed semantically than for those processed physically or phonemically. Following Tulving and Bower (1974) it is argued that if the initial encoding of the memory trace was primarily semantic, then a recognition test which involved choices between target words and their synonyms should be more difficult than if the initial processing had been physical or phonemic. Such a position appears reasonable on the basis of the study by Anisfeld and Knapp (1968) in which subjects made more false recognition responses to associates and synonyms than to control words. If this should occur in this study, then recognition for target words processed semantically might well be no better than that for words following a complex physical processing task. Though such a finding would not invalidate the depth hypothesis, it would argue against the version quoted above. Therefore, in this study, the recognition tests used were

composed of target words paired with their synonyms.

The tasks chosen to represent the phonemic and physical domains were also changed from Experiment I. A rhyming task was used to represent phonemic processing. This task had been used in several previous levels of processing studies and was felt to yeild a more complete processing of the word than did the tasks used in Experiment I. For the semantic domain it was felt important to employ a task which did not use category labels, so that these labels would not be available as cues at retrieval. Thus, for semantic processing, subjects were required to assess whether words were opposite in meaning.

The mixed-list design of the first study was modified so that any problems created by subjects' use of selection strategies in switching from one task to another would be avoided. In this study a within-subjects, between-lists design was employed.

The major aim of this study was to test the prediction that any semantic analysis would be more beneficial for retention than any physical analysis--a prediction crucial to maintenance of the domains of processing assumption. The test was biassed against support of the prediction both by use of a complex physical task, and by the structure of the recognition test.

Depth of processing and effort

Criticisms of the physical tasks used in Experiment I suggested that these tasks did not require complete processing of words in the study list. If this was the case then it could be argued that differences in retention following, say, physical and semantic processing might reflect differences in the amount of effort involved in processing of those tasks. Walsh and Jenkins (1973) made a similar argument with respect to the orienting tasks used in their study. Although Walsh and Jenkins did find support for this effort hypothesis, their method of investigation was rather molar, involving the examination of effects of various combinations of orienting tasks on subsequent recall.

For this study a different method was used to gain evidence about the relationship between depth of processing and effort. The task involved use of an unattended list which was presented simultaneously with the target list.

The rationale for use of this method was based upon the premise that the individual's limited-capacity processing system is subject to control by subject-initiated strategies which can be influenced by task demands (Posner and Synder, 1975). If orienting tasks may impose different demands upon the processing system, then these demand differences should be reflected in differential retention of an unattended list common to all orienting tasks. Hence if one orienting task places greater demands on, or requires more effort from, the

processing system, then the level of retention for the unattended list should be lower than that following less demanding orienting tasks. If such differences in effort were relevant to the orienting tasks said to be representative of different 'depths' of processing, then the characterization of depth would perhaps be more quantitative than qualitative.

Experiment II was therefore concerned with two aspects of the description of depth of processing as a qualitative construct:

1. The overriding importance of a semantic analysis for subsequent memory of an event; and

2. the amount of effort involved in different types of processing.

Method

Subjects

The subjects were 63 undergraduate students taking Introductory Psychology courses who participated to fill course requirements. Subjects were tested in groups of between eight and twelve and were randomly assigned to treatment conditions. The unanalyzed protocols of seven subjects were rejected due to incorrect recording of responses. In the recall condition over half the subjects failed to follow directions for the cued recall tests and

thus this data was not analysed in this study.

Stimuli

Three 60 word lists were chosen from the Toronto word pool. This word pool comprises a group of unrelated, two-syllable words between five and eight letters in length, all having a Thorndike-Large (1940) frequency rating of A or A-A. The lists were equated for total frequency using the norms of Kucera and Francis (1967). For study list presentation each of the target words was paired with a comparison word of equivalent frequency. Comparison words were either unrelated to, or were rhymes, or antonyms of, the target words. At time of presentation, a target word and its comparison word were presented on the same slide. Target words, printed in upper case, were positioned centrally on the slide, while comparison words, in lower case, appeared in the bottom right area of the slide. A typical presentation was similar to the examples below:

AROUZE	TOUGH	UNITE
status	rough	divide
LIST 1	LIST 2	LIST 3

Due to the method of presentation of stimuli in these lists it was not possible to apply each of the orienting tasks to each list. However, prior to the first experimental session, lists were tested for difficulty level. The lists used in

the study were of equivalent levels of difficulty.

For the recognition tests three distractor lists were prepared. Words in these lists were chosen to be of equivalent frequency to the target words. All words in the distractor lists were synonyms of target words, so that each test item in the recognition test involved a choice between a target word and its synonym.

A final list of 60 words was chosen for auditory presentation as the unattended list. Words in this list were chosen at random from the same source as words on the study lists, though words with obvious physical, phonemic or semantic relationships to words on the study lists were excluded. The study lists and the unattended list were of equivalent total frequency.

For subjects in the recall conditions a cued-recall test was given following completion of the free recall test. As indicated above the data from the cued recall test was to a large extent spoiled by subjects' failure to follow instructions, and was therefore excluded from any analysis.

Procedure

Subjects were assigned randomly to one of two groups according to the type of retention test (recall or recognition) which followed study list presentation. Three orders of study list presentation were used for each group, so that each type of task was done as first, second, or

third list for both groups.

At the start of an experimental session subjects were informed that the experiment involved two key aspects; a perceptual decision-making task carried out during study-list presentation, and a test of retention. Thus all groups in this study were tested under intentional learning conditions for all three lists. Subjects were told that the playing of the unattended list was simply to provide an interference task to which they need not attend. Before presentation of each study list groups were reminded of the task and given examples of the task for practice. (Instructions given to subjects are included in Appendix 4.5).

Words were prepared as slides and were projected onto a screen using a Kodak Carousel projector, the operation of which was controlled from the tape-recorder. Each slide was visible for 2 sec. The intertrial interval was 3 sec. Subjects recorded their responses on prepared sheets.

During the first list seen at each session, the words on the unattended list were played over the speakers of a Sony TC630 stereophonic taperecorder. The onset of the study word on the screen and the unattended word on the tape was simultaneous. These events were synchronized using a Kodak Sound Synchronizer which placed a pulse on one track of the tape. This signal then triggered the change mechanism of the projector so that the presentation of both study and unattended lists was controlled from the tape recorder. This

system was also utilized for presentation of the remaining study lists; during presentation of these lists the speakers of the tape recorder were disconnected.

Following completion of a study list subjects were first given a 2-min. filler task which involved multiplication of 3-digit numbers, and were then given the appropriate retention test. Recognition groups received a 2AFC test in which each test item involved a choice between a target word and its synonym. Recognition tests were presented on an overhead projector, items being presented at a 7 sec. rate. Recall groups were first given 4 min. for free recall and then 3 min. to complete the cued recall test. Once subjects had completed the retention test for items on the first study list, they were unexpectedly given a 2-AFC recognition test for the words presented on the unattended list. This test was also presented on an overhead projector, items being presented at a 4 sec. rate. This test followed only the first study list presented at each testing session. All responses were recorded in prepared test booklets.

Results

Depth of processing and domains

Recognition

The recognition results are shown in Table II-1. Means for the physical, phonemic, and semantic tasks respectively

were 72.4%, 71.2% and 77.5%. As in Experiment I the semantic task resulted in the highest level of recall though this level is somewhat below the levels of recognition present in the previous study. This drop in level of recognition following semantic tasks is most likely due to the change in the nature of the recognition test used in this present experiment. The relationship between the levels of recognition following physical and phonemic tasks is changed from that present in Experiment I. Here, the level of recognition following the more complex physical processing is slightly superior to that for the rhyming task.

Analysis of variance of percentage correct recognition indicated a significant main effect for domain: $\underline{F}(2,68)=7.32$, $p<.01$. Individual comparisons between means for domains using the Newman-Keuls procedure, (Winer, 1962 p.309) showed that the recognition for words processed semantically was significantly better than for words given physical and phonemic processing at the .05 level. The difference between mean recognition following semantic and physical processing did not achieve significance using the more conservative Tukey procedure (Winer, 1962, p.87). Details of these analysis are included in Appendix 4.2. The ANOVA summary table for the recognition group is given in Appendix 4.1.

The above result does support the prediction made by Craik and Tulving (1975) that semantic analysis is more beneficial for recognition than even a complex physical

analysis.

Recognition for words given Yes responses is consistently superior to that for words given No responses. The ANOVA showed that the main effect for response type was significant: $\underline{F}(1,34)=31.24$, $p<.001$. The results here follow those obtained by Craik and Tulving (1975) in Experiment 2. The Domain x Response Type interaction was not significant.

Although the recognition results in this experiment do support the strong version of the domain hypothesis stated by Craik and Tulving (1975), two reservations must be kept in mind. The superiority of semantic over physical domain recognition is not highly significant. Furthermore the original domain hypothesis of Lockhart et al. (1975) is still not given definitive support, for in this study, the levels of the recognition performance following physical and phonemic processing are equivalent.

Recall

Recall results are given in Table II-2. As was the case in Experiment I recall levels are low. The major point of difference between these results and those for the previous study is the marked drop in recall following completion of the semantic task Performance for physical and phonemic tasks does not differ from that in Experiment I.

Analysis of variance of percentage correct recall for this group showed that the main effect for domain was not

significant: $\underline{F}(2,54)=0.061$. The main effect for response type was highly significant: $\underline{F}(1,27)=47.64$, $p<.001$, reflecting the superiority of recall for words given Yes over those given No responses. The Domain x Response Type interaction was not significant. The summary table for this analysis is given in Appendix 4.3.

Table II-1

Percentage correct recognition as a function of processing domain and response type.

RESPONSE	DOMAIN		
	Physical	Phonemic	Semantic
YES	75.9	73.9	80.7
NO	68.9	68.6	74.2

Table II-2

Percentage correct recall as a function of processing domain and response type

RESPONSE	DOMAIN		
	Physical	Phonemic	Semantic
YES	9.0	9.7	10.4
NO	3.8	3.8	3.5

As in Experiment I, the recall results do not provide a good test of the domain hypothesis largely because of the very low level of performance. It is clear from Table II-2 that these levels were unexpectedly low for the semantic task, especially when levels of recall for words given semantic processing in Experiment I are used as a point of comparison. It is important to note that in Experiment II no category labels were available for use as cues as was the case in Experiment I. This point will be taken up in discussion of these results.

Depth of processing and effort:

The pattern of recognition performance for items on the unattended list, for the recognition and recall groups, is shown in Figure II-1. Levels of correct recognition are very similar following each of the three processing tasks. Analysis of variance of percentage correct recognition confirmed this similarity in performance. There was no significant main effect for task previously performed for recognition (F 2,31=0.23) or recall ($F(2,30)=0.76$). These findings provide no support for the position that the different processing tasks used in this study differ with respect to effort.

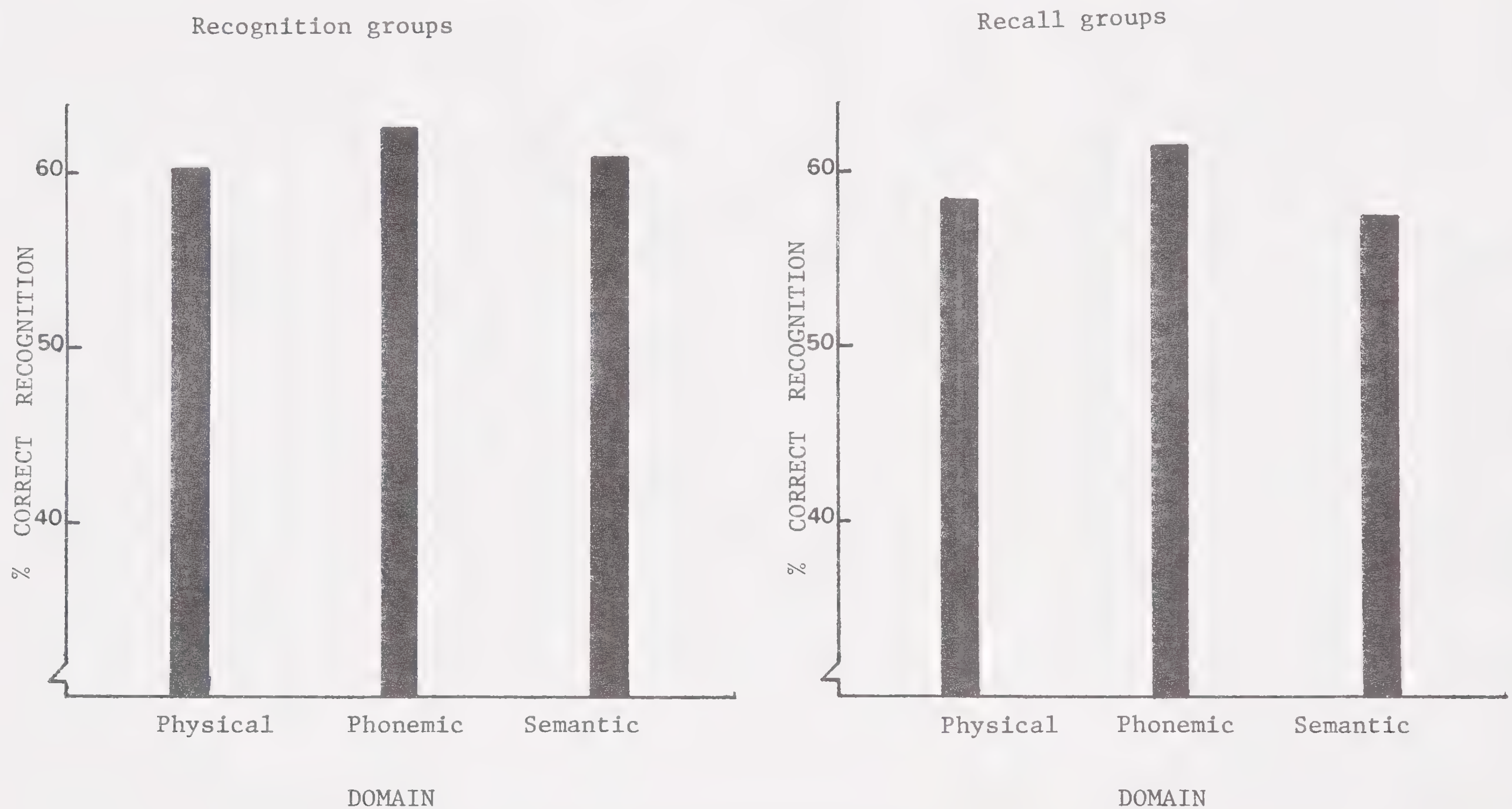

FIGURE II-1. Recognition performance on the Unattended List: Recall and Recognition groups.

Discussion

This study was intended to provide evidence on two questions of relevance to the levels of processing view of memory. The results support predictions made on the basis of the model in two instances, yet raise questions about the details of one major aspect of the model.

The effort hypothesis is not supported. There is no evidence from this study that the tasks within the various processing domains differ with respect to processing demands, in a quantitative sense. This conclusion is based upon the similarity in level of recognition performance for items on the unattended list. These results support the position argued by Walsh and Jenkins (1975) that differences in retention following various orienting tasks are not simply the result of differences in processing load, or effort. Hence the emphasis on qualitative aspects of processing as being most important for influencing retention is well placed.

Craik and Tulving's (1975) strong version of the domain hypothesis is supported by the recognition results from this study. Semantic processing was more beneficial for recognition that the complex physical processing. Obviously the hypothesis under test is not universally acceptable on the basis of results from this one study, especially since the significance of the effect, in statistical terms, was marginal. Yet the result is sufficiently supportive of the domain hypothesis to encourage further research on this

topic.

The changes made in the tasks, and in the nature of the recognition test, appear to have worked in the intended fashion. Recognition for the physically processed words is quite high relative to that for words processed phonemically, expecially since phonemic recognition is similar to that found in other studies (Craik and Tulving, 1975). On the other hand, the level of performance following the semantic task is somewhat lower than that found in previous studies, although without use of a control group which completed an unconstrained recognition test for the same words, it is not possible to argue conclusively that the change in the test procedure effected the drop in performance. On the basis of results from the Anisfeld and Knapp (1968) study, such an inference might be justified.

The major problem raised by the present results is one which relates to the specification of the hierarchy of domains by Lockhart et al. (1975). In their paper these authors propose the existence of three qualitatively distinct domains: physical, phonemic, semantic. The viability of such a distinction must be open to question. In this study there is a clear divergence from this pattern; the differences expected between physical and phonemic domains were not present in these results. A similar pattern was also present in Experiment I.

While the recall results are all at a low level, the recall for words processed semantically is worthy of note.

On the basis of the recognition results it can be argued that the task did encourage a deep level of processing. Yet such a conclusion is certainly not possible in the case of recall. A number of possibilities emerge in consideration of this result.

The pattern of performance of the recall group may be a function of a low level of processing, although the recognition results argue against such a position. The results may represent a consistent 'basement' effect as a result of the recall task being inordinately difficult, irrespective of the orienting task undertaken. Though this appears as a likely explanation of the physical and phonemic recall levels in this study, and in Experiment I, it is not clear why the performance on semantic tasks should be so much reduced in comparison to that found in studies utilizing similar list length. The nature of the task is one possible locus of this change in level of performance. The antonym task has not previously been used in the levels of processing procedure (to present writer's knowledge), and this low level of performance might well be characteristic of other tasks. The categorization and sentence completion tasks which have resulted in relatively high levels of recall are perhaps unique, in the sense that they establish "relational encodings" for target words. A positive response to a categorization or sentence completion task does include the word within a context. A positive response to the antonym question perhaps operates to <u>exclude</u> a word from a given context. If this is the case the lower level of recall

may result from such a low level of congruity in responses. Such an explanation would however argue against a definition of depth of processing in terms of distinct processing domains. All these explanations must be regarded as speculative until subjected to further test.

One obvious objection to the doubts raised about qualitative differences between domains on the basis of the present results centres around the nature of the physical task used. It could be argued that this 'physical' task is really 'semantic', and that the failure to find differences between the two tasks used here support this view. While such an argument cannot be refuted at present, its use points to two major problems inherent in the levels of processing approach as it is presently conceived.

The first problem is concerned with the scaling of tasks, or with their classification as semantic, phonemic, or physical. Though there are some guidelines for deriving characteristics peculiar to each type of task, the possibility must be entertained that any processing of a word involves some semantic processing. Encoding bias models (Meyer, Schvaneveldt, and Ruddy, 1974) have been proposed as one way of resolving this difficulty and in fact the levels of processing approach utilizes such an approach. The encoding bias model allows for some semantic coding, but assumes that the predominant bias of the encoding effected by a phonemic task is phonemic. The problem with such models is that of establishing, *a priori*, satisfactory

classification system which allows a suitably sound basis upon which to make predictions about effects of qualitatively different tasks.

The second problem is closely related to the first, though it is perhaps more general. How much physical processing makes a task physical, as opposed to phonemic or semantic? This is a problem raised, essentially, by the postulating of qualitative differences between processing domains and it may be a problem associated with all qualitative distinctions (Brainerd, in press).

In regard to both the above problems it appears that further work on development of the levels of processing model must be concerned with utilization of a more precise scale of depth of processing. This point will be taken up in the Concluding Discussion section of this thesis.

The most significant findings emerging from this study are:

1. The strong version of the domain hypothesis proposed by Craik and Tulving (1975) is supported by results here. This support must at present be qualified because of the marginal statistical significance of the result.

2. There is no evidence from this study that differences in processing load, or effort, were involved in the orienting tasks used.

3. The hierarchy of domains postulated by Lockhart et al. (1975) is subject to question in light of both these results, and more general problems concerned with specification of such a hierarchy.

EXPERIMENT III

Recent studies of developmental aspects of memory point to at least two major differences in the memory processes of children and adults. The first is a difference in use of control processes, or strategies, in memory. The second is a difference in the products of processing-a difference in the nature of the memory trace. Both points are of central concern in the levels processing model, although this model has not been applied in any systematic way to the study of children's memory. The present study is concerned with the recall and recognition performance of children using the levels of processing approach.

Control processes and development

The first difference noted above was given prominence by Flavell (1970) when he proposed that the construct of a 'production deficiency' characterized memory processes in the young child. A production deficiency is apparent when processes or strategies which would facilitate performance on a task are not produced, and hence not used. Flavell argued that such a deficiency was manifested in the performance of young children on tasks requiring use of strategies such as rehearsal. There is a considerable amount of evidence which indicates that although young children do not spontaneously use rehearsal strategies they can be

trained to do so, with good results (Ashcraft & Kellas, 1974; Belmont & Butterfield, 1971; Brown, Campione,Bray&Wilcox,1973). Such a pattern of results typifies the production deficiency described by Flavell. A similar view has been advanced by Rowher (1973) with respect to use of elaboration strategies - the "generation of a common referent for the items to be coupled" (p.5) in a paired - associate type task. The developmental change described by Rowher is similar to that detailed by Flavell (1970); spontaneous use of the strategy is not present in childhood, but is in evidence in adolescence. Thus some type of discontinuity is postulated in the development of control processes. Hagen (1971) also supports such a view.

Attributes and development

The second difference mentioned above can be associated with a view described by Underwood (1969; 1972) that the memory trace be conceived of as an 'ensemble of attributes' or features extracted during the initial stages of processing of an event. Research stemming from this position has suggested that there are differences in the relative importance of various attributes at different ages. Bach and Underwood (1970) found that acoustic attributes contributed more to errors on a recognition task than did associative attributes for second-grade children, but that the reverse was true for sixth-graders. Felzen and Anisfeld (1970) noted a similar pattern for their third- and sixth-grade subjects; false recognitions were predominantly acoustic for the

younger children, whereas both semantic and acoustic errors were frequent in performance of sixth-graders. Freund and Johnson (1972) unconfounded orthographic and acoustic attributes and found that, while errors of false recognition were equally frequent for both attributes in Grade 3, the orthographic attribute appeared to be dominant for first-grade children. Similar results were obtained by Cramer (1972), and in free recall for critical items by Hasher and Clifton (1974), both of whom found a change in the salience of different attributes with increasing age. From these results authors postulate a discontinuity in relative dominance of orthographic/acoustic and semantic attributes in the memory of children and adults.

Consideration of each of these two postulated discontinuities, in use of control processes and in attribute dominance, in relation to the levels of processing model leads to apparently conflicting predictions.

If the production deficiency is as described by Flavell (1970) it should not be operative in the incidental learning procedure typically used in levels of processing studies. The production deficiency, in the case of rehearsal, is overcome once rehearsal instructions are provided (Hagen, Hargrave & Ross, 1973). Orienting tasks such as those used in Experiments I and II above, would be equivalent to the prompts used in studies such as that by Hagen et al. (1973), and thus would be expected to initiate control processes or strategies appropriate to carrying out those particular

tasks. Furthermore, if semantic orienting tasks initiated elaborative rehearsal strategies (Mazuryk & Lockhart, 1974), then one would expect that memory for words processed semantically would be better than that for words given physical or phonemic processing. Thus if it is a difference in use of control processes that, on its own, distinguishes children's memory processing from those of adults then it would be predicted that use of orienting tasks similar to those used in the previous experiments should produce a similar pattern of results: semantic processing should result in better recognition or recall than either physical or phonemic processing tasks.

A different prediction would be derived from the results of the attribute studies. On the basis of those studies, using subject populations similar to the one used here (average age 9.1 years), phonemic, and possibly physical, processing tasks should result in retention which is superior, or comparable, to that of semantic tasks. Stated in a weaker form, it would be predicted that the importance of semantic processing tasks for subsequent recall and recognition in adults, should be much reduced in the case of the children used in this study.

Hence the first major question in this study will involve an examination of the patterns of recall and recognition performance of children, following physical, phonemic, and semantic processing tasks.

Simultaneous and successive processing

As indicated in the review of literature a final study was planned to investigate more thoroughly the memory aspects of the simultaneous -successive processing model. A further object of this study was to attempt to relate levels of processing to simultaneous-successive processing. Largely due to expansion of the first part of the project from one to two experiments the major part of this intended final study could not be as extensive as planned. Initially it was intended to provide data on overt rehearsal strategies, and organization, in addition to the two points which form the focus of the experiment. However, the subjects given recall and recognition tests in this study were also given tests of similtaneous and successive processing. Thus it was possible to include scores from the recognition test in a factor analysis with the other test scores.

Method

Subjects

Subjects were 150 Grade 4 children, both males and females, in normal classrooms in the Edmonton Separate School System. The average age was 9.1 years with a range from 8.1 to 10.4 years. The five schools from which subjects were tested were relatively homogenous with respect to socioeconomic status (SES). No formal measure of SES was used. The children were expected to be from the average to high ranges of intelligence as no special classes were included in the sample. From school records the average verbal intelligence of the sample was 107.4 as measured by the Canadian Lorge Thorndike Intelligence test, though the range was quite wide, being from 77 to 145. Testing was carried out in the classrooms in normal class sizes by two experimenters. The protocols of 20 subjects were rejected due to failure of subjects to follow instructions either during recording of responses or at time of test. The majority of these rejected protocols involved improper recording of Yes or No responses, or spoiling of recognition tests by selection of both or none of the alternatives.

Stimuli

Two 36 word lists were developed for the experiment. The words were concrete words chosen largely from the ratings of Paivio, Yuille and Madigan (1968) and Van de Veur (1975). Five words not rated in the above norms were used,

while twelve other words were rated according to their stems (golden- gold) or to words of comparable meaning (railway-railroad) included in the norms.

One word list was used as the study list, the other was used to provide distractors on the two-alternative forced-choice recognition (2AFC) test. Two orders of the study list were prepared; both word order and question type-to-word order were randomized on both list orders.

Procedure

The procedure adopted in this study followed closely that used in Experiment 1. The words on the study list were prepared as slides and were projected onto a screen using a Kodak Carousel projector. Presentation of each word was preceded by a question played over a tape recorder. Questions required a Yes or No answer and subjects recorded their responses on prepared sheets. Two minutes after completion of the study list half the subjects received sheets containing a 2AFC recognition test, while the other subjects were given free recall instructions.

Three question types were used in this study. Each question type was chosen to be representative of one of the three domains of processing proposed by Lockhart, Craik and Jacoby (1975). The questions were similar to those used in previous investigations of levels of processing (Craik, 1973), the wording being modified to suit the children in this study. The three questions used were

Physical: Is the word printed in capital letters?

Phonemic: Does the word rhyme with *(Train)*?

Semantic: Is the word an example of an *(Animal)*?

Prior to the start of the session subjects were given each type of question and asked to explain what it meant. Several examples of each type of question were given to the group of subjects and suitable responses were discussed. In addition a practice list was then given to acquaint subjects with the slide and tape aspects of the test. This list contained examples of each type of question and subjects were required to practice recording of their decisions on the sheets. All subjects were informed that the test involved a decision-making task; they were not informed of the retention tests which would follow.

Questions and slides were presented at a 4 sec. rate. Following completion of the study list, sheets for the retention tests were distributed. After approximately two minutes subjects were given appropriate retention instructions. Half the subjects were given free recall instructions, the others were informed about the recognition procedure. Subjects were not given a time limit for the retention tests, though most subjects completed the tests within 4 min.

The other tests administered to subjects were tests which had been used in previous investigations of simultaneous-successive processing (Das et al. 1975). Tests were administered in a different order to each of the eight

classes tested. Complete randomization of administration order of tests was not achieved, due primarily to constraints arising from the time schedules of the children tested. Digit span, Word Reading, and Color Naming tests were administered individually. All other tests were given to groups of class size. The tests were:

1. Raven's Progressive Matrices, (Raven, 1965). Designed as a test of general, non-verbal reasoning this test involves completion of a coloured matrix in each of 36 items.
2. Figure Copying, (Ilg & Ames, 1964). This test requires the subject to copy a geometrical figure while the figure is in view.
3. Memory For Designs, (Graham & Kendall, 1960). This test was designed initially as a test of brain-damage. Subjects are shown simple geometric shapes for five seconds, and are then required to draw each shape from memory. Each shape was prepared as a slide and was projected onto a screen. 15 figures are presented.
4. Visual Short-term Memory. Subjects view a five-digit grid for five seconds. After offset of the grid subjects are given a filler task, identifying a color on a chart, and are then required to reproduce the grid exactly as presented. 20 grids are presented.
5. Serial Recall. 24 set of four words are presented auditorily to subjects. Twelve sets of the words are acoustically related, twelve are unrelated. Words are presented on a tape recorder at a 2 sec. rate.

Immediately after presentation of each set subjects are required to write down the words in order of presentation.

6. Digit span. Subjects are read lists of digits of increasing length. Digits are presented at a 1 sec. rate. The task requires subjects to recall digits in the order of presentation. The score is the length of the longest list successfully recalled.
7. Word Reading. The names of four colours are printed in black in each of 10 rows. The 40 words were prepared on a slide. The task requires subjects to read through the list of 40 words, row by row, as quickly as possible. Scores represent time taken to complete this task.
8. Color Naming. This test requires subjects to name the colours of 40 strips presented in the same way as in the Word Reading tests. The subjects' time to name each of the 40 strips is taken as the score on this test.

RESULTS

As in the previous experiments the dependent variables of interest here were percentage correct recognition (hits) and percentage correct recall. Due to the fact that both boys and girls were tested in different schools, the first analysis carried out checked for differences in overall performance associated with sex or school effects. In the case of recognition neither school nor sex differences appeared to play a major role. Analysis of variance of total list performance indicated that main effects due to sex and

school were not significant; for sex - $F(1,75)=0.43$ $p>.5$; for school $F(4,72)=1.34$ $p>.25$. Thus further analysis of the recognition data was carried out without reference to sex or school of subjects.

For recall, although the effect of school was not of major importance, there were differences in level of recall for boys and girls, with the girls performing at a higher level. Analysis of variance for total recall indicated that the main effect for school was not significant: $F(4,66)=1.06$, $p>.38$. The superiority of recall performance of the girls was significant: $F(1,69)=5.24$ $p<.03$. For this reason analysis of recall data was carried out separately for boys and girls.

Levels of processing in children

Recognition

Table III-1 presents the mean percentage correct recognition as a function of domain and type of response. In general the pattern typical of the depth of processing studies with adults is also present in recognition performance of these Grade 4 children; performance increases across domains. Recognition levels are quite high and may, for recognition of words processed semantically, indicate presence of a ceiling effect; however such high levels of recognition appear in other studies using this procedure, even those employing a different type of recognition test (Craik & Tulving, 1975).

In terms of the predictions discussed in the introduction to this study a most important relationship is that between levels of recognition following the phonemic and semantic tasks. From Table III-1 it is clear that the level of recognition following the rhyming task used here is considerably higher than it is in Experiment II. Analysis of variance of percentage correct recognition indicated a significant main effect for domain: $\underline{F}(2,126)=25.96$ $p<.01$, with the means for the physical, phonemic and semantic domains being 80.8, 89.2 and 92.7 respectively. Individual comparisons of these

TABLE III-1

Percentage correct recognition as a function of processing domain and response type

	DOMAIN		
Response	Physical	Phonemic	Semantic
YES	79.4	87.7	94.6
NO	82.2	90.8	90.8

means indicated that both the semantic and phonemic recognition was superior to that for the physical tasks, though the former two were not significantly different (see Appendix 5.5). Neither the main effect for response type nor the Domain x Response Type interaction were significant. The summary table for this analysis is included in Appendix 5.1.

Recall

Recall results for boys and girls are reported separately, and are given in Table III-2. These results are also shown in Figure III-1. Two major differences in pattern of response are apparent. The first is a difference in level of performance; mean percentage recall was higher for girls than for boys (18.9 vs 14.8). The second difference is related to response type; most noticeably for the phonemic task. For boys, recall for words given a Yes response was significantly better than for those given No responses (F (1,31)=5.4, $p<.05$). This is not the case for girls(see Appendix 5.3). The reason for the difference lies primarily in the divergence of performance after negative responses to the rhyming questions. Girls recalled both types of words with equivalent frequency.

In other respects the recall results are similar for both boys and girls. Recall following semantic processing tasks is far superior to that following either physical or phonemic processing, a result which follows the pattern

TABLE III-2

Percentage correct recall as a function of processing domain and response type for Boys and Girls

BOYS			
	DOMAIN		
Response	Physical	Phonemic	Semantic
YES	4.1	11.5	36.5
NO	12.8	8.3	15.3

GIRLS			
	DOMAIN		
	Physical	Phonemic	Semantic
YES	5.0	16.3	38.3
NO	13.7	15.3	24.6

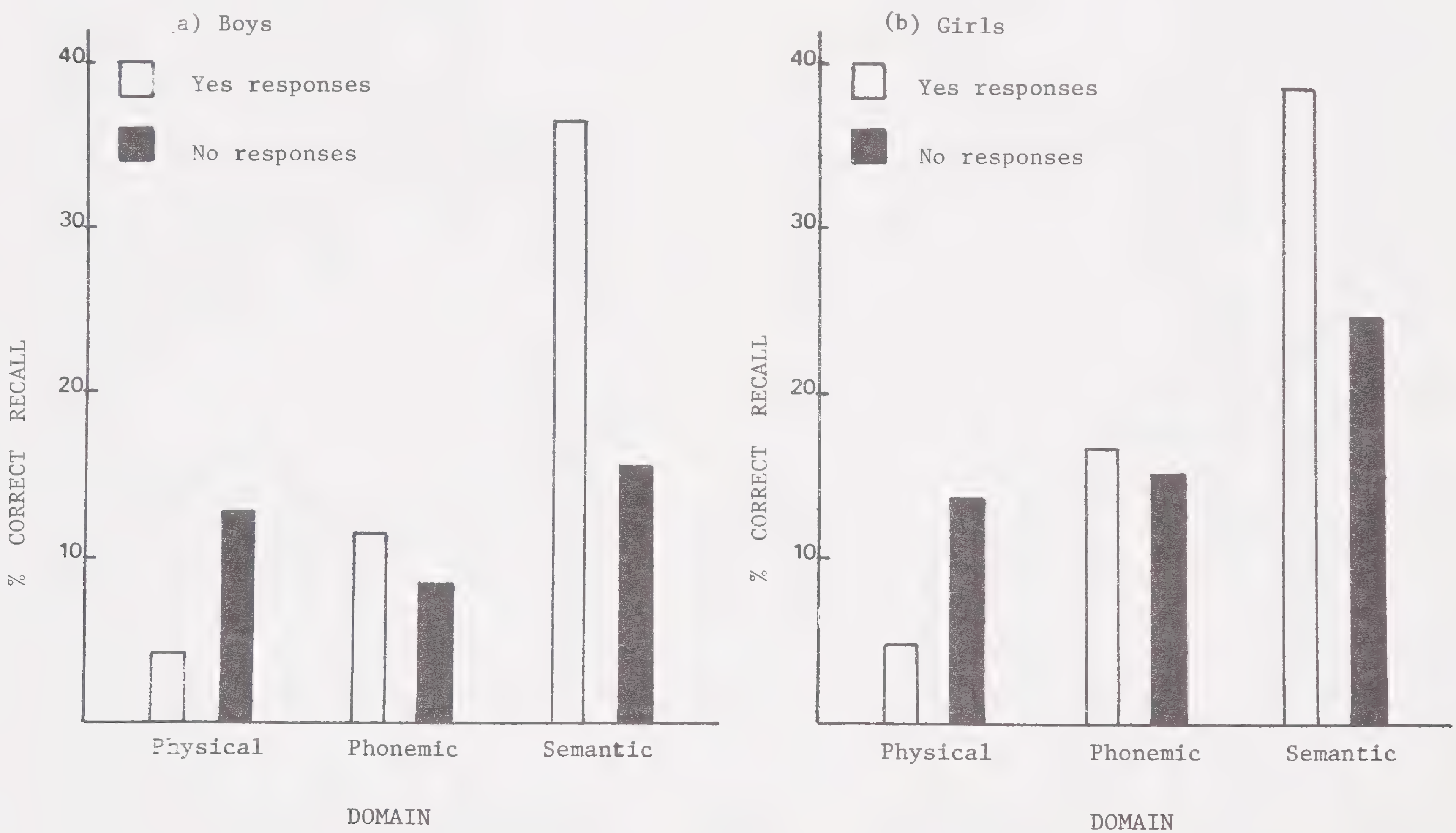

FIGURE III-1. Recall performance as a function of processing domain and response type for: (a) Boys; and (b) Girls.

found in studies with college students.

The significant Domain x Response Type interactions, present for both boys ($\underline{F}(2,62)=19.0$, $p<.01$) and girls ($\underline{F}(2,64)=6.78$, $p<.01$), reflect the changing relationship between recall levels for Yes and No responses on the physical and semantic tasks. The same pattern is present for both boys and girls. Although recall for words given positive responses is better than for negative decisions on phonemic and semantic tasks, the magnitude of the difference is significant only for the boys. Summary tables for the analyses of variance of percentage correct recall are included in Appendixes 5.2 and 5.3.

Levels of processing and IQ

For the recognition group a post-hoc division of subjects into top and bottom thirds was made on the basis of scores on the Verbal intelligence scale of the Canadian Lorge-Thorndike Intelligence test (1967). Mean IQs for the High and Low IQ groups were 91.1 and 124.9 respectively. There were 19 subjects in each group.

The mean percentage correct recognition for the two groups is given in Table III-3. These results are depicted in Figure III-2. There is a difference in level of recognition performance; the means for the groups being

TABLE III-3

Percentage correct recognition as a function of processing domain and response type: High and Low IQ Groups

	HIGH IQ (n=19)		
	DOMAIN		
Response	Physical	Phonemic	Semantic
YES	84.7	88.6	97.4
NO	82.3	95.7	95.3
	LOW IQ (n=19)		
YES	75.6	79.7	93.7
NO	80.6	87.9	82.9

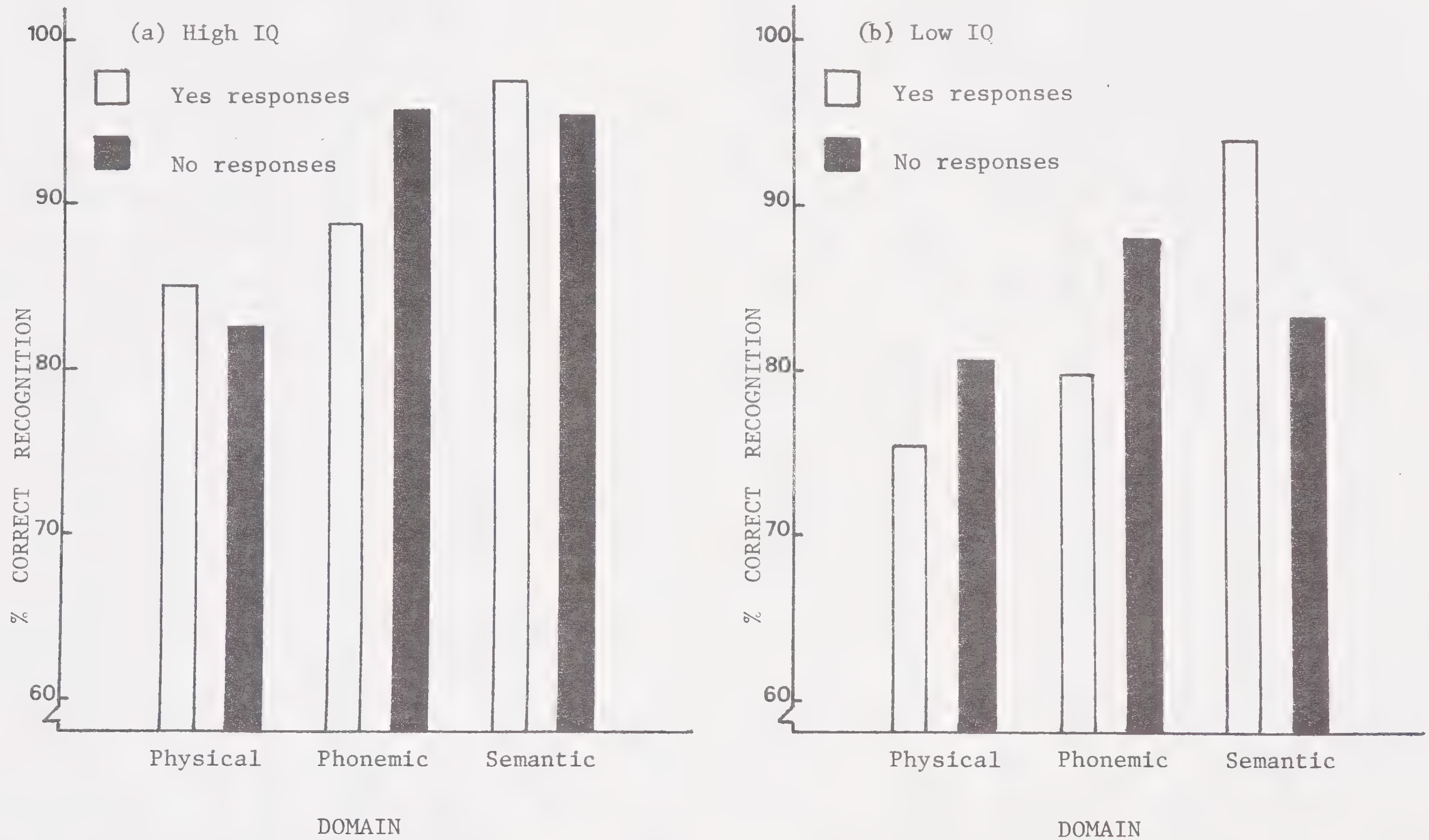

FIGURE III-2. Recognition performance as a function of processing domain and response type for: (a) High IQ; and (b) Low IQ groups.

90.7 (High IQ) and 83.4 (Low IQ). Analysis of variance of this data indicated that this difference in level of performance was significant: $\underline{F}(1,36)=5.9$, $p<.02$.

Apart from the difference in level, the pattern of performance for the two groups is quite similar. The semantic tasks result in higher levels of recognition than do the rhyming and case tasks. As is the case in the recognition group as a whole, performance on the phonemic task is considerably better for children at both IQ levels than it is for the college subjects who carried out the same task in Experiment II.

Simultaneous and successive processing

Analysis of tests in the battery described previously was affected by a similar pattern of sex differences to that reported in the discussion of the free recall results. For the free recall groups differences in performance between girls and boys were present when the tests were considered as a whole. A two group, one-way, fixed effects Multivariate Analysis of Variance (MANOVA) was carried on scores for all tests and indicated a significant difference between boys and girls: $\underline{F}(9,61)=2.24$; $p<.03$; Wilks $x=0.75$. Subsequent unvariate analyses of variance indicated that girls scored significantly higher on Raven's Progressive matrices ($\underline{F}(1,63)=4.34$, $p<.05$), whereas boys did better on the Color Naming task ($\underline{F}(1,63)=4.0$, $p<.05$). The division of the recall group reduced the sample to a size unsuitable for factor

analysis. For this reason the recall group was excluded from further consideration in relation to simultaneous and successive processing.

A similar analysis was carried out for the recognition group. MANOVA with this group showed no significant difference due to sex: $F(9,67)=1.59$, $p>.13$; $=0.82$.

Scores for the recognition group on the nine tests are given in Table III-4. Table III-5 gives the intercorrelations of the tests.

TABLE III-4

Mean (x) and standard deviation (s.d.) for Grade 4 Recognition group (n=77)

	TEST	X	s.d
1.	Raven's Progressive Matrices (RPM)	28.03	4.77
2.	Figure Copying (FC)	13.42	2.97
3.	Memory For Designs (MFD)	41.84	3.01
4.	Serial Recall (SR)	56.61	11.02
5.	Visual Short-term Memory (VSTM)	80.14	13.15
6.	Digit Span (DS)	5.42	1.02
7.	Word Reading (WR)	21.85	4.13
8.	Color Naming (CN)	33.04	6.57
9.	Recognition Memory (RO)	87.93	8.34

TABLE III-5

Correlation matrix for Grade 4 Recognition Group (n=77)

TEST		1	2	3	4	5	6	7	8	9
Raven's Progressive Matrices	1	1.0	.454	.485	.270	.333	.144	-.086	-.291	.108
Figure Copying	2		1.0	.412	.351	.315	.263	-.114	-.126	.144
Memory for Designs	3			1.0	.217	.094	.072	.049	-.089	.149
Serial recall	4				1.0	.532	.462	-.174	-.119	.332
Visual STM	5					1.0	.398	-.431	-.230	.294
Digit Span	6						1.0	-.241	-.120	.240
Word Reading	7							1.0	.552	-.231
Color Naming	8								1.0	-.175
Recognition Memory	9									1.0

TABLE III-6

Factor Analysis (Varimax Rotation) for Grade 4 Recognition Group (n=77)

Test	I	II	III	h^2
Raven's Progressive Matrices	.106	.807	-.214	.708
Figure Copying	.328	.689	-.014	.582
Memory For Designs	.020	.825	.062	.686
Serial Recall	.792	.252	.027	.691
Visual short-term Memroy	.705	.173	-.314	.626
Digit Span	.761	.032	-.026	.581
Word Reading	-.303	.090	.828	.785
Color Naming	-.021	-.183	.876	.802
Recognition Memory	.537	.054	-.173	.321
Variance	2.204	1.946	1.633	
% of TOTAL Variance	24.49%	21.63%	18.14%	
Total Variance accounted for	64.26%			

As in previous studies involving investigation of simultaneous and successive processing a principal components analysis was carried out followed by a varimax rotation (Gorsuch, 1974). The criterion used for number of factors extracted was an eigenvalue greater than one.

The factor loading matrix for the recognition group is given in Table III-6. The pattern of factor loadings follows closely that found in previous studies of simultaneous and successive processing in Grade 4 children (Das et al., 1975). Serial Recall, Visual STM, Digit Span, and Recognition Memory all load highly on Factor 1, a pattern which is similar to that of factors representing successive processing in previous studies. Factor II is defined by high loadings on Raven's Progressive Matrices, Figure Copying, and Memory for Designs. The loading of the latter test on this factor suggests that the involvement of memory is not unique to tests loading on Factor I; the Memory for Designs test also requires subjects to hold information, of a spatial nature, for subsequent reproduction. Factor II is similar to simultaneous processing factors identified by Das et al. (1975).

Factor III is defined by tests both of which are speeded, and thus reflects speed of information processing. Once again this pattern of factor loadings is similar to that found in studies reviewed by Das et al. (1975).

The results of the principal components analysis for the Grade 4 group follow closely the pattern identified in

previous studies of simultaneous and successive processing. The new test added in this study, Recognition memory, is apparently related most closely to tasks requiring successive processing.

Discussion

Levels of processing in children

The pattern of recognition performance gives support to the view that phonemic processing has a greater influence on children's memory than it does on that of adults. This conclusion is in substantial agreement with the findings of studies showing changes in the salience of acoustic and semantic attributes with changes in age. The implication of these recognition results is that the proposed hierarchy of processing domains (Lockhart et. al., 1975) may well operate differently for adults than it does for children. The influence of semantic processing may not play the dominant role in children's memory that it does in adults'. In children of this age, semantic and phonemic processing may have similar importance for retention. Thus the prediction given most support by the recognition results is that based on attribute research,such as that of Bach and Underwood (1970) and Freund and Johnson (1972). The findings in the latter study are very similar to those emerging here; phonemic and semantic attributes were of equal importance, though both were more influential than orthographic attributes for Grade 3 subjects.

The recognition results here must be subject to one

important reservation. If the high levels of recognition performance represent a ceiling effect then the importance of the semantic task for recognition would be underestimated. Should subsequent studies indicate this to be the case the similarity in levels of recognition following phonemic and semantic tasks may disappear.

The position of the physical processing domain (represented by the case task here) is similar to that in studies with adult populations. If, as Freund and Johnson (1972) claim, the orthographic (physical) attributes of words are most salient in the processing of very young children this salience would appear to diminish by the time children reach Grade 4.

The pattern of recall results differs from that just described for recognition. The dominant influence of the categorization task for subsequent recall is clearly evident for both boys and girls. This finding does not support the prediction derived from studies of attribute salience which give acoustic attributes a influence similar to that of semantic attributes. Here, the processing of semantic attributes is clearly most important for recall, a finding which is compatible with a depth of processing viewpoint. Murphy and Brown (1975) have recently reported a similar result in a recall study with pre-school children. In their study the categorization task resulted in significantly greater recall than either phonemic or physical tasks. Murphy and Brown quote (p. 521) results of another

unpublished study in which semantic tasks facilitated recall to greater extent than did physical tasks, even when physical processing was a preferred clustering dimension. In a further experiment Murphy and Brown (1975) used two semantic tasks, the categorization task and a pleasantness rating task used by Hyde and Jenkins (1973). The level of free recall was similar for both tasks which suggests that the observed facilitation was not limited to use of a categorization task.

The reasons for the difference in patterns of results for recall and recognition procedures are not provided by data in this study, but two alternative explanations can be suggested. First, it is possible that there was actually a ceiling effect in the recognition data. As described above, for this to bring the recognition results into line with the pattern of free recall, it is necessary to assume that any ceiling effect restricted recognition following semantic tasks. A more difficult recognition test might remove this ceiling effect and indicate a dominant influence of the semantic tasks in recognition as well as in recall. The validity of this explanation can be tested in a further study.

A different explanation centres upon the nature of the recall and recognition tests. These tests differ, obviously, in the <u>amount</u> of information each supplies to the subject at time of retrieval - as observed by Lockhart et al. (1975). However, the two tests also differ with respect to the <u>type</u>

of information they supply at time of retrieval. The recognition test supplies the target word complete with all its features or attributes. If, for children, the phonemic attribute is particularly salient, then its provision soon after presentation of the target word may serve to facilitate recognition to a degree similar to that associated with semantic processing. In recall, the absence of such information may act to depress retrieval of phonemic information. Such an argument clearly does nothing to diminish the powerful influence of semantic processing which, subject to the same handicap in free recall tasks, results in relatively high levels of performance. Use of phonemic cues in a cued recall study might provide some evidence for, or against, such an argument. Murphy and Brown(1975), in their study with pre-school children, did use a cued-recall procedure. However their cues, category labels, were unlikely to have accessed phonemic features of the memory trace.

Sex differences in recall

The sex differences found in recall in this study are similar to those reported in several recall studies (Amster & Wiegard, 1972; Finley and Frenkel, 1972; Shepard & Ascher, 1973), though explanation of such differences is not attempted here. Maccoby and Jacklin (1974), in their survey of sex differences in many areas, regard the verbal superiority of girls at around age 11 years to be one of four sex differences "that are fairly well established" (p.

351). These authors found no suitable explanations for this difference.

Levels of processing and IQ

Any interpretation of the IQ results must be seen as tentative; it is founded on a rather meagre data base in this study. The levels of processing paradigm may, however, be a fruitful procedure for investigating processing differences in IQ ranges lower than the low average group studied here. One rationale for extending this investigation would be to gain evidence related to studies of encoding in trainable mentally retarded (TMR) children (Luria & Vinogradova 1959; Das,Note 2) which argue for a lack of semantic categorization in the TMR, using quite different experimental procedures. From the present study any differences in recognition performance of low average and high average IQ groups do not appear to be due to differences in pattern of processing. In studies with lower IQ groups, comparisons between intentional and incidental learning conditions may also be rewarding. Recently, several workers have implicated intention or planning as a major difference in processing characeristics of normal and retarded groups(Brown,1974;Das,1973). The effect of such a difference may be further explicated using a levels of processing procedure.

<u>Simultaneous-successive processing and recognition</u>

The results in this study extend in a minor respect the findings of previous investigations of the simultaneous-successive model of processing. Taken together with the results of past studies, the present findings suggest that the model has stability for a relatively wide range of cognitive tasks. As higher order processing styles the two modes of information integration have a heuristic value. The stability of the factors across several studies suggests that this is the case. Statements of a more specific nature are not appropriate at this stage of development of the model, as will be apparent in the discussion of the Recognition Memory scores given below.

At least two areas of commonality can be detected for the four tests having high loadings on Factor 1; each test is a direct test of memory; and each to some degree involves retention of order information. It has been argued above that involvement of memory in these tests is not on its own sufficient to provide a unique characterization of this factor; another test of memory, Memory for Designs, loads on a different factor. In a further testing of the subjects involved in this study, as part of another research project , scores on both concrete and abstract paired-associate tests did not load with those for the four tests identifying Factor I in this study. This reinforces the argument that this is not a memory factor. The factor loading matrix for this further analysis is included in Appendix 5.4.

Serial recall, Visual STM and Digit Span tests all make explicit the requirement that subjects retain information about the order of presentation of stimulus elements. In each test the load of information is comparable, four to five elements, and the retention interval similar, about five seconds. These tests are therefore all tests of recent, or episodic, memory (Tulving, 1972).

The Recognition Memory test does not explicitly require subjects to retain order information. In addition, the load imposed on memory is much greater than in the previous three tests (36 elements in this study), and the retention interval longer - about two minutes. The reason for its correlation with the other three tests is thus not clear. One suggestion is that order information is influential in this task by virtue of its being a test of episodic memory. Lockhart et al. (1975) take up a suggestion made by Murdock (1974) that recent memory is similar in nature to a conveyor belt, with items ordered in a temporal sequence on this belt. From this metaphor Lockhart et al. propose that subjects employ a scanning strategy at time of retrieval, a tracing back through events in episodic memory. If this scanning strategy was in fact involved in the recognition test, then order of presentation would be a relevant variable. Such a suggestion is of course speculative.

The labelling of Factors II and III is less controversial. All tests defining Factor II require processing of spatial information. The nature of the

processing is quite diverse, encompassing memory for spatial configurations, spatial reasoning and a more direct test of perceptual processes (Figure Copying). As indicated above, the two tests defining Factor III both require speeded performance - subjects are instructed to perform as fast as is possible. Thus the labelling of this factor as Speed of Processing is more direct.

The loading of the Recognition Memory test raises a problem of interpretation. Consideration of this problem indicates that, at present, knowledge of the locus of the involvement of a particular mode of processing (such as successive processing) is limited: In traditional memory terms, it is unclear as to whether the effect of processing is most important at encoding, storage, or retrieval stages. Thus the use of tests which tap more specific abilities will produce more specific factors in a factor analysis. Such a pattern is evident in a study by Jarman(1975) in which the inclusion of quite specific modality-matching tests resulted in extraction of a modality-matching factor in a factor analysis. Further development of the simultaneous-successive model, for purposes of remediation, should include investigation of more specific abilities.

SUMMARY AND CONCLUDING DISCUSSION

Depth of processing is important for memory. The general pattern of results in all three Experiments shows this to be the case; deeper (semantic) processing yielded higher levels of both recall and recognition performance than did more shallow processing tasks. At this general level, the levels of processing model is supported by the results of the studies reported here.

The definition of depth remains a problem. The results of Experiment II do not support the proposal by Lockhart et al. (1975) that depth can be seen in terms of three, hierarchically arranged, processing domains. In particular, this proposal does not provide a satisfactory taxonomy of tasks which are not semantic. In Experiment II, and to a lesser extent in Experiment I, performance on physical and phonemic tasks did not follow that pattern which would be predicted from the domain hypothesis. The domain hypothesis should be investigated in further experiments. A wider range of tasks, both semantic and non-semantic should be used, and their effects on memory assessed. The constrained recognition procedure used in Experiment II could be expanded to gain evidence for encoding biases which were non-semantic. Just as synonyms were used as distractors in the 2AFC recognition test used in Experiment II, physical and phonemic distractors could also be used as distractors

for target words.

While spread of processing is an appealing construct, the evidence for it, as within-domain elaboration, is limited here to the recall results following semantic tasks in Experiment I. The only other study directly concerned with an investigation of spread (Craik&Tulving, 1975; Experiment 7), was also limited to investigating semantic processing with recall tests. It is not the effect of stimulus elaboration which is being questioned here. Rather it is the specification of spread as processing within the particular domains suggested by Lockhart et al. (1975) which appears to be unsatisfactory.

There is support for the role of stimulus elaboration when it is considered in terms of Schulman's (1974) congruity, or relational encoding. The facilitative effects of elaborate tasks and positive responses were most apparent in the List 3 results in Experiment I, though positive responses were better recalled and recognized in both Experiments II and III. Hence it does make sense to talk of levels of processing in terms of degree of stimulus elaboration. It is when the nature of the elaboration is specified by Lockhart et al. (1975), and also by Craik and Tulving (1975), in terms of qualitatively distinct processing domains, that theory and data diverge.

Knowledge of test did not prove to be an advantage for absolute levels of performance. However the recall results for List 3 in Experiment I did show that different

processing strategies may be used for processing of non-semantic aspects when subjects are preparing for recall and recognition tests. Effects of intention to recall appear to be most important for the non-semantic tasks. When semantic processing is undertaken, its influence is such that it overcomes any disadvantage associated with ignorance of the particular type of test. It has also been argued here that this finding is of relevance for explanation of the superior level of recall in intentional, as opposed to incidental, learning situations. This finding suggests that the levels of processing procedure will be useful for further investigations of optimal encoding strategies. It should also be noted that these strategies are by definition operative in intentional learning situations.

Experiment III indicated that the levels of processing procedure will be a fruitful approach to study of both development, and individual differences, in memory. In this study, the results support the view that different features of the stimulus are important to differing degrees for children and adults. Within the limitations of this study it is clear that phonemic processing was more important for the Grade 4 children than it was for the adults in Experiment II. This finding needs to be replicated and extended. Replication is needed, because of the possibility of a ceiling effect in the recognition data, and also because of the differences in recall and recognition patterns. The experiment could be extended to encompass both different age levels, and different ability groups.

The difference in the Low Average and High IQ groups is one of level, not a difference in pattern of processing. The finding suggests that the levels of processing procedure could be employed to examine processing in groups lower on the IQ scale. Such a view has been recently outlined by Brown (1974). The consideration of processes in relation to retardation follows that given to processing in the normal memory. Researchers in retardation are beginning to move away from the search for a specific structural deficit in memory (usually STS, see Scott & Scott, 1968). Recent views have tended toward descriptions of processing by retardates in terms of control processes, strategies, and planning. In this sense memory is not an isolated deficit in the retardate; it may be just one area in which processing is inadequate or inefficient. Thus to the extent that the psychologist can affect performance of retardates, it is with processes that he must be concerned.

Craik and Lockhart (1972) have achieved their objective. They have given a "new way to interpret data" and have provided a "heuristic framework" which has been used in research. They have not, however, provided the final memory model.

The levels of processing model has served to reemphasize important principles in psychology. At the most general level the qualitative aspects of processing have been given prominence. Craik and Lockhart, like Jenkins (1974) have indicated the central importance of semantic

processing for memory. Through the work which has stemmed from this model the nature of rehearsal research has been significantly changed; what was previously a catch-all concept has taken on the beginnings of a systematic framework. The levels of processing view has also helped to reinforce the interest in control processes. Finally, the "heuristic framework" can be seen as having potentially important applications in instructional and remedial settings.

The levels of processing model as it now stands (Craik & Jacoby, 1975; Craik & Tulving, 1975; Lockhart et al., 1975) has some weaknesses. The major problem is the definition of depth. It would appear from the studies reported here that the definition couched in terms of processing domains may not be the ultimate one. Several other definitions, basically sympathetic to Craik and Lockhart's (1972) original view, have been suggested. Bower (1975) and Herriot (1974) suggest that depth be interpreted in terms of the number and quality of attributes encoded. Herriot (1974) has also suggested that depth reflects the variety of forms of encoding registered at acquisition. Bower and Carlin (1975) hypothesized that amount of detail was the crucial element in depth. There is little evidence available at this stage to prefer one explanation over the others, and it could be argued that each of these explanations is less useful in a theoretical sense than that proposed by Lockhart et al. (1975). At least the latter writers have provided a definition which can be subjected to

experimental investigation.

Kolers (1975) remains a strong critic of the levels of processing approach. While much of his thinking is very similar to that of Lockhart et al. (1975), he does reject both the qualitative basis for depth of processing effects which they propose, and the emphasis given to semantic processing in their model. For Kolers it is the actual operation undertaken during processing of the stimulus event which is crucial for subsequent retrieval. Also, in his view practiced encoding is not conscious, it is automatic; it is the unusual encoding which necessitates conscious analysis of the stimulus. Thus Kolers argues that it is only in this sense of unskilled performance that conscious analysis will produce superior performance (recognition); once the subject becomes skilled at the previously unusual task his retention level will drop.

In general terms the views of Kolers and Lockhart et al. are compatible. Both accept the role of practice and the effect of unusual processing; unskilled processing is equivalent to spread in Lockhart et al's terms. In specific details the two views are incompatible. Kolers (1975) would reject claims of Craik and Tulving (1975) that semantic analyses must be more beneficial for memory than physical analyses. In Kolers' view it would seem that practice could eventually overcome any advantage resulting from habitual use of semantic processing. Given subjects of sufficient persistence this disagreement could be investigated

empirically.

Two final problems have been mentioned in the discussion of Expermient II results. The first is perhaps rhetorical in nature: any qualitative distinction always raises a problem of how much? - how much semantic processing makes a task _not_ a physical processing task, how much formal operations makes a task _not_ a concrete operations task?

The second problem is less obtuse. It is the problem associated with the scaling of levels of processing. It would appear necesary that future research in levels of processing take up the argument proposed by Lockhart et al. (1975) for a scale of depth and extend it into areas other than the domains proposed in that paper. Other models of levels of processing and available (Kintsch, 1975; Marslen-Wilson & Tyler, 1976; Miller, 1974). Marslen-Wilson & Tyler (1976) recently defined levels of processing with reference to a psycholinguistic model, and then tested recall performance following various processing tasks. In both their experiments the results supported the predictions they made on the basis of the psycholinguistic model. The results of the experiments described in this thesis suggest that such an approach is needed if the levels of processing position is to yield more definitive, and more useful, results.

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Note 1

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Note 2

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APPENDIX 1

Materials prepared for Experiment 1

Appendix 1.1: List of Categories used in Categorization Tasks: Experiment 1

actions
aggression
animals
art
celebration
clothing
complexity
crime
direction
education
emotions
entertainment
exploration
finance
food
geography
health
history
industry
land
literature
living things
locations
mathematics
measurement
media
movement
occupations
peace
personal qualities
plants
pleasant things
possessions
quantity
recreation
size
speech
substances
technology
time
tools
transport
unpleasant things
war

Appendix Word lists used in Experiment 1

LIST A		LIST B		LIST C	
admire	briefly	enter	pardon	union	prairie
evening	trifle	prayer	cheerful	meantime	model
lemon	except	fortune	castle	handsome	exchange
rocky	speaker	complain	blossom	venture	valley
refer	banner	limit	journal	instant	accept
police	upright	involve	feather	jersey	gentle
machine	alas	partly	intend	wander	happy
highly	explain	poem	approve	refuse	canvas
feeble	restless	lucky	calmly	shipping	famous
needle	current	pupil	arouse	hungry	blessing
palace	infant	quarrel	modern	garment	southern
abroad	discuss	artist	confirm	turkey	striking
pursuit	silence	column	theater	attach	comfort
expose	dealer	mirror	project	suspect	illness
collect	oyster	helpless	content	struggle	acne
willow	gallant	precious	swiftly	carriage	theory
hatred	shortly	harvest	beside	couple	loudly
appeal	working	empire	berry	attack	channel
foolish	splendid	powder	latter	dislike	mention
frozen	movie	engage	mission	quickly	muscle
navy	canoe	behind	advise	cabin	scholar
ready	heavy	greatly	likely	endure	arrest
apply	despise	maker	sober	apple	fury
tribute	chapter	create	wanting	table	attempt
depart	boundary	princess	occur	item	major
motor	argue	replace	bedroom	sleeping	constant
career	coming	pasture	image	costume	income
wicked	mistake	middle	moral	immense	proclaim
relief	alone	suggest	painting	butcher	sprinkle
signal	disease	lumber	thinking	lying	million

APPENDIX 2

ANOVA Summary Tables for Recognition and Recall Groups in Experiment 1: LISTS 1 and 2.

APPENDIX 2.1

ANOVA Summary Table for Group RORO: Lists 1 and 2

SOURCE	DF	SS	MS	F
SUBJ	20	22525.21		
W1 (LIST)	1	124.50	124.50	0.529
EW1B	20	4704.92	235.25	
W2 (DOMAIN)	2	55087.38	27543.69	79.878**
EW2B	40	13792.91	344.82	
W3 (ELABORATION)	1	1062.27	1062.27	1.980
EW3B	20	10728.46	536.42	
W4 (RESPONSE TYPE)	1	37.62	37.62	0.138
EW4B	20	5455.67	272.78	
W12	2	176.02	88.01	0.222
EW12B	40	15884.34	397.11	
W13	1	404.47	404.47	1.678
EW13B	20	4819.58	240.98	
W14	1	14.64	14.64	0.053
EW14B	20	5565.56	278.28	
W23	2	1586.89	793.45	3.458*
EW23B	40	9178.43	229.46	
W24	2	943.23	471.62	1.886
EW24B	40	10001.28	250.03	
W34	1	390.61	390.61	1.144
EW34B	20	6829.75	341.49	
W123	2	1367.08	683.54	3.006
EW123B	40	9094.25	227.36	
W124	2	670.88	335.44	1.029
EW124B	40	13042.31	326.06	
W134	1	728.40	728.40	4.035
EW134B	20	3610.75	180.54	
W234	2	611.76	305.88	0.723
EW234B	40	16911.76	422.79	
W1234	2	413.27	206.63	0.517
EW1234B	40	15978.13	399.45	
W	483	209217.11		

* $p<.05$ ** $p<.01$

APPENDIX 2.2

ANOVA Summary Table for Group RORA: Lists 1 and 2

SOURCE	DF	SS	MS	F
SUBJ	22	16448.90		
W1 (LISTS)	1	433.72	433.72	0.709
EW1B	22	13464.16	612.01	
W2 (DOMAIN)	2	65049.63	32524.82	81.659**
EW2B	44	17525.15	398.30	
W3 (ELABORATION)	1	273.43	273.43	1.095
EW3B	22	5493.16	249.69	
W4 (RESPONSE TYPE)	1	639.41	639.41	2.572
EW4B	22	5470.04	248.64	
W12	2	382.31	191.61	0.686
EW12B	44	12255.24	278.53	
W13	1	251.37	251.37	0.778
EW13B	22	7103.63	322.89	
W14	1	63.01	63.01	0.161
EW14B	22	8595.43	390.70	
W23	2	2019.78	1009.89	4.136*
EW23B	44	10742.58	244.15	
W24	2	936.13	468.07	1.788
EW24B	44	11520.24	261.82	
W34	1	627.84	627.84	1.592
EW34B	22	8676.71	394.40	
W123	2	32.51	16.25	0.049
EW123B	44	14624.91	332.38	
W124	2	277.07	138.54	0.387
EW124B	44	15741.17	357.75	
W134	1	182.39	182.39	0.479
EW134B	22	8382.49	381.02	
W234	2	1079.34	539.67	1.644
EW234B	44	14441.40	328.21	
W1234	2	193.89	96.94	0.362
EW1234B	44	11773.68	267.58	
W	529	238251.82		

* $.01 < p < .025$ ** $p < .01$

APPENDIX 2.3

ANOVA Summary Table for Group RARA: Lists 1 and 2

SOURCE	DF	SS	MS	F
SUBJ	22	5186.67		
W1 (LISTS)	1	1805.44	1805.44	11.191**
EW1B	22	3549.18	161.33	
W2 (DOMAIN)	2	33425.05	16712.52	60.388**
EW2B	44	12177.15	276.75	
W3 (ELABORATION)	1	3540.08	3540.08	16.195**
EW3B	22	4808.89	218.59	
W4 (RESPONSE TYPE)	1	1129.76	1129.76	3.361
EW4B	22	7393.98	336.09	
W12	2	228.79	114.40	0.755
EW12B	44	6670.92	151.61	
W13	1	832.02	832.02	4.597*
EW13B	22	3981.45	180.98	
W14	1	2.97	2.97	0.019
EW14B	22	3431.03	155.96	
W23	2	3290.26	1645.13	5.522**
EW23B	44	13109.52	297.94	
W24	2	3665.16	1832.58	9.032**
EW24B	44	8927.84	202.91	
W34	1	108.12	108.12	0.388
EW34B	22	6126.04	278.46	
W123	2	0.51	0.26	0.001
EW123B	44	9016.84	204.93	
W124	2	173.84	86.92	0.443
EW124B	44	8637.60	196.31	
W134	1	410.98	410.98	2.525
EW134B	22	3580.35	162.74	
W234	2	478.22	239.11	0.857
EW234B	44	12281.97	279.14	
W1234	2	553.73	276.87	0.872
EW1234B	44	13972.03	317.55	
W	529	167309.73		

* $.01<p<.05$ ** $p<.01$

APPENDIX 2.4

ANOVA Summary Table for Group RARO: Lists 1 and 2

SOURCE	DF	SS	MS	F
SUBJ	27	25100.35		
W1(LISTS)	1	1637.19		5.724*
EW1B	27	7722.01	286.00	
W2(DOMAIN)	2	66973.34	33486.87	79.393**
EW2B	54	22776.28	421.78	
W3(ELABORATION)	1	4450.12	4450.12	10.796**
EW3B	27	11129.67	412.21	
W4(RESPONSE TYPE)	1	3581.15	3581.15	17.307**
EW4B	27	5586.94	206.92	
W12	2	14.67	7.34	0.050
EW12B	54	7931.17	146.87	
W13	1	6.23	6.23	0.027
EW13B	27	6182.46	228.98	
W14	1	104.11	104.11	0.508
EW14B	27	5532.44	204.91	
W23	2	5539.53	2769.77	11.639**
EW23B	54	12850.57	237.97	
W24	2	7863.54	3931.77	20.419**
EW24B	54	10397.93	192.55	
W34	1	291.64	291.64	1.204
EW34B	27	6537.47	242.13	
W123	2	24.63	12.32	0.090
EW123B	54	7373.70	136.55	
W124	2	813.21	406.60	2.249
EW124B	54	9763.12	180.80	
W134	1	1.35	1.35	0.004
EW134B	27	9270.65	343.36	
W234	2	115.65	57.83	0.240
EW234B	54	13008.01	240.89	
W1234	2	2709.19	1354.60	4.182*
EW1234B	54	17493.25	323.95	
W	644	247681.24		

* $.01<p<.05$ ** $p<.01$

APPENDIX 2.5

Newman-Keuls comparisons between ordered means: Group RORO

Domains: ordered means.

	Physical	Phonemic	Semantic
	68.9	76.3	93.9
68.9	—	7.4	25.0
76.3		—	17.6
93.9			—

	r=	2	3
q. (r,40)		2.86	3.44
q. (r,40)		11.58	13.93
q. (r,40)		15.47	17.70

	Physical	Phonemic	Semantic
	68.9	76.3	93.9
68.9		—	**
76.3			**
93.9			

** p<.01

APPENDIX 2.6

Newman-Keuls comparisons between ordered means: Group RORA

Domains: ordered means.

	Physical	Phonemic	Semantic
	67.7	75.7	93.7
67.7	—	8.0	26.0
75.7		—	18.0
93.7			—

	r=	2	3
q. (r,44)		2.86	3.44
q. (r,44)		12.44	14.96
q. (r,44)		16.62	19.01

	Physical	Phonemic	Semantic
	67.7	75.7	93.9
68.9	—		**
76.3			**
93.9			

** p<.01

APPENDIX 3

ANOVA Summary Tables for Recognition and Recall groups on Expected/Unexpected Tests: Experiment 1, List 3

APPENDIX 3.1

ANOVA Summary Table for recognition performance on List 3: Expected vs Unexpected tests

SOURCE	SS	DF	MS	F	P
TOTAL	254129.374	587.	432.929		
BETWEEN	39293.848	48.	818.622		
A (EXPECTATION)	759.068	1.	759.068	0.9258	0.3409
ERROR	38534.779	47.	819.889		
WITHIN	214835.527	539.	398.582		
B (DOMAIN)	40792.818	2.	20396.409	58.5719	0.0 *
AB	2065.557	2.	1032.779	2.9658	0.0564
ERROR	32733.461	94.	348.228		
C (ELABORATION)	0.287	1.	0.287	0.0010	0.9755
AC	687.626	1.	687.626	2.2751	0.1382
ERROR	14205.507	47.	302.245		
D (RESPONSE TYPE)	2478.456	1.	2478.456	10.5283	0.0022*
AD	154.854	1.	154.854	0.6578	0.4214
ERROR	11064.267	47.	235.410		
BC	237.370	2.	118.685	0.3323	0.7181
ABC	459.447	2.	229.723	0.6431	0.5279
ERROR	33576.283	94.	357.195		
BD	1887.615	2.	943.807	3.5932	0.0314*
ABD	765.204	2.	382.602	1.4566	0.2382
ERROR	24690.764	94.	262.668		
CD	26.829	1.	26.829	0.0991	0.7543
ACD	883.717	1.	883.717	3.2632	0.0773
ERROR	12728.371	47.	270.816		
BCD	286.374	2.	143.187	0.4134	0.6626
ABCD	2553.853	2.	1276.926	3.6868	0.0287*
ERROR	32556.867	94.	346.350		

* $.01<p<.05$

APPENDIX 3.2

ANOVA Summary Table for recall performance on List 3: Expected vs Unexpected Tests

SOURCE	SS	DF	MS	F	P
TOTAL	156608.484	551.	284.226		
BETWEEN	22792.132	45.	506.492		
A(EXPECTATION)	656.965	1.	656.965	1.3059	0.2593
ERROR	22135.167	44.	503.072		
WITHIN	133816.352	506.	264.459		
B(DOMAIN)	28153.940	2.	14076.970	70.5486	0.0 **
AB	2224.408	2.	1112.204	5.5740	0.0053*
ERROR	17559.139	88.	199.536		
C(ELABORATION)	1756.940	1.	1756.940	10.9419	0.0019**
AC	290.725	1.	290.725	1.8106	0.1853
ERROR	7065.073	44.	160.570		
D(RESPONSE TYPE)	4451.757	1.	4451.757	23.8444	0.0000**
AD	24.630	1.	24.630	0.1319	0.7182
ERROR	8214.822	44.	186.700		
BC	2560.399	2.	1280.200	8.5199	0.0004**
ABC	402.158	2.	201.079	1.3382	0.2676
ERROR	13222.939	88.	150.261		
BD	8920.563	2.	4460.282	24.9754	0.0 *
ABD	213.343	2.	106.671	0.5973	0.5525
ERROR	15715.651	88.	178.587		
CD	336.836	1.	336.836	2.0106	0.1632
ACD	174.769	1.	174.769	1.0432	0.3127
ERROR	7371.340	44.	167.540		
BCD	1037.858	2.	518.929	3.7484	0.0274*
ABCD	1936.304	2.	968.152	6.9933	0.0015*
ERROR	12182.758	88.	138.440		

*

**

Appendix 4

ANOVA Summary Tables for recognition and recall groups: Experiment II.

APPENDIX 4.1

Summary Table for Recongition Group: Experiment II

SOURCE	DF	SS	MS	F	P
SUBJ	34	10267.03			
WI (DOMAIN)	2	1534.84	767.42	7.319	<.01
EW1B	68	7130.24	104.86		
W2 (RESPONSE					
	1	2052.34	2052.34	31.241	<.01
EW2B TYPE)	34	2233.59	65.69		
W12	2	28.51	14.26	0.218	
EW12B	68	4451.67	65.47		
W	175	17431.19			

TSQ/N= 1140640.16 N= 210 SST= 27698.23

STORAGE REQUIRED= 26/10000

APPENDIX 4.2

Newman-Keuls comparisons between ordered means: Recognition group

Domains: ordered means.

	Phonemic	Physical	Semantic
	71.2	72.4	77.5
71.2	—	1.2	6.3
72.4		—	5.1
77.5			—
		r= 2	3
q. (r,68)		2.83	3.40
q. (r,68)		4.89	5.88

	Phonemic	Physical	Semantic
	71.2	72.4	77.5
71.2		—	*
72.4			*
77.5			

* $p<.05$

Note: The Tukey procedure (Winer, 1962, p.87) uses the critical value q(3,68). =5.88 for all comparisons. Using this procedure the difference between means 3 -2 is not significant at the .05 level.

APPENDIX 4.4

ANVOA Summary Table: Recognition groups-percentage correct recognition on unattended list as function of previous task.

Source	SS	MS	DF	F	P
Groups	34.19	17.09	2	0.23	0.79
Error	2348.94	75.77	31		

ANOVA Summary Table: Recall groups-percentage correct recognition on unattended list as function of previous task.

Source	SS	MS	DF	F	P
Groups	95.81	47.91	2	0.76	0.48
Error	1890.75	63.02	30		

Appendix 4.5

Instructions for Experiment II

This experiment involves working with words. I'm going to show you three lists of words on the screen and have you carry out a specific task on each word in the list. After each list I will give you some problems to do and will then test your memory for the words presented on the screen. Any questions?

I'm interested in three types of information in this experiment. First I am interested in your performance on the perceptual decision-making task. This information is provided in your responses to the words as you go through the list. For each word you will be asked to give a Yes or No response, and to write Y or N in the spaces on Page 1 of your booklet. Let's look at an example. (sample slide shown, tasks explained). Any questions?

The second type of information which is of interest is your performance on the problems which will be given after we finish going through a list. Finally I am also interested in how well you can remember the words which were on the list.

The words which I want you to remember are those printed in capital letters in the centre of each slide. (Sample slide shown). It is these words in capital letters which will be the subject of the retention test. These words, in lower case are only for use in the decision you

APPENDIX 4.3

Summary Table for Recall Group: Experiment II

SOURCE	DF	SS	MS	F
SUBJ	27	1395.16		
W1(DOMAIN)	2	2.25	1.12	0.061
EW1B	54	988.99	18.31	
W2(RESPONSE				
	1	1297.59	1297.59	47.640
EW2B TYPE)	27	735.42	27.24	
W12	2	75.96	37.98	1.578
EW12B	54	1299.33	24.06	
W	140	4399.54		

TSQ/N= 8130.12 N= 168 SST= 5794.69

STORAGE REQUIRED= 26/10000
10:29:36 .781 RC=0

make for each word. These words, in lower case, will not be tested in the retention test. Remember that it is the words printed in capitals that will be the subject of the retention test. Any questions?

While you are going through this first list you will hear a list of words being played over the speakers. This is an interference task so don't worry about the words. I'm using this task to see whether it interferes with your carrying out of the decision task. You don't have to worry about the words being played over the speakers. Concentrate on the slide.

O.K. We will start on the (first) list. Remember that your task on this list is to (<u>decide whether or not the words rhyme</u>). Make a decision for each slide. Work quickly so that you don't fall behind. Are there any questions before we start?

APPENDIX 5.1

ANOVA Summary Table for recognition: Experiment III

Source	DF	MS	SS	F	
Subjects	63	28001.06			
W1 (Domain)	2	9661.79	4830.90	25.96	**
Error W1B	126	23447.69	186.9		
W2 (Response Type)	1	51.48	51.48	0.317	
Error W2B	63	10215.71	162.15		
W12	2	975.46	487.73	2.24	
Error W12B	126	27419.62	217.62		
W	320	71771.75			

**p<.01

APPENDIX 5.2

ANOVA Summary Table for recall: Experiment III: Boys

SOURCE	DF	SS	MS	F	
Subjects	31	11011.39			
WI(DOMAIN)	2	12033.19	6016.60	19.044	**
Error W1B	62	19587.63	315.93		
W2(Response Type)	1	1312.00	1312.00	5.438	*
Error W2B	31	7478.78	241.25		
W12	2	7237.56	3618.78	19.010	**
Error W12B	62	11802.48	190.36		
W	160	59451.63			

* .01<p<.05
** p<.01

APPENDIX 5.3

ANOVA Summary Table for recall, Experiment III: Girls

SOURCE	DF	MS	SS	F	
Subjects	32	12064.73			
W1(DOMAIN)	2	17074.55	8537.28	32.566	**
Error W1B	64	16777.81	262.15		
W2(Response Type)	1	203.64	203.64	0.854	
Error W2B	32	7630.15	238.44		
W12	2	4117.56	2058.78	6.782	**
Error W12B	64	19428.47	303.57		
W2	165	65232.18			

** p<.01

APPENDIX 5.4

Factor Analysis (Varimax Rotation) for Grade 4 Recognition Group: Expanded Battery (n=77)

Test	I	II	III	h^2
1. Raven's Progressive Matrices	.763	.151	-.138	.624
2. Figure Copying	.653	.345	.040	.547
3. Memory for Designs	.726	.065	.147	.553
4. Serial recall	.354	.721	-.013	.645
5. Visual STM	.167	.710	-.294	.618
6. Digit Span	-.054	.821	.029	.677
7. Word reading	.073	-.335	.811	.775
8. Color naming	-.194	-.036	.852	.765
9. Concrete Paired-Associates	.615	-.123	-.261	.462
10. Abstract Paired-Associates	.458	.283	-.142	.310
11. Recognition memory	.116	.476	-.214	.286
Variance	2.337	2.278	1.647	

APPENDIX 5.5

Newman-Keuls comparisons between ordered means: Recognition groups

Domains: ordered means.

	Physical	Phonemic	Semantic
	80.8	89.2	92.7
80.8	—	8.4	11.9
89.2		—	3.5
92.7			—

		r= 2	3
q.	(r,126)	2.80	3.40
q.	(r,126)	4.79	6.16
q.	(r,126)	6.33	7.18

	Physical	Phonemic	Semantic
	80.8	89.2	92.7
80.8		**	**
89.2			—
92.7			

** p<.01

APPENDIX 5.6

Summary Table for Recognition Performance, Experiment III

High and Low IQ groups.

SOURCE	SS	DF	MS	F	P
TOTAL	69756.847	227.	307.299		
BETWEEN	21223.867	37.	573.618		
A(IQ)	3012.761	1.	3012.761	5.9557	0.0197
ERROR	18211.106	36.	505.864		
WITHIN	48532.980	190.	255.437		
C(DOMAIN)	5128.849	2.	2564.424	12.2352	0.0000
AC	96.512	2.	48.256	0.2302	0.7949
ERROR	15090.709	72.	209.593		
D(RESPONSE TYPE)	40.759	1.	40.759	0.2163	0.6447
AD	0.063	1.	0.063	0.0003	0.9855
ERROR	6784.878	36.	188.469		
CD	1890.224	2.	945.112	3.6051	0.0322
ACD	625.637	2.	312.818	1.1932	0.3092
ERROR	18875.349	72.	262.158		